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Lowering Farm Job Costs . . .

FARM jobs in the process of mechanization and refinement range from those which must be done several times daily to some which may be required only once a year or once in a lifetime. Between these two extremes there are many operations which leave a wide range of choice as to when, where, and how they are done.

Corn shelling, for example, may be done by a large, mobile unit, as shown above, which can justify the investment cost by use on a large number of farms, low labor requirement, low operating cost per unit of capacity, and low overall cost to the farmer for getting the job done and out of the way for a year in a few hours or days. Or corn shelling may be done at low cost daily or weekly, as needed, with small farm-owned shellers representing a low investment cost, and using farm family labor which might otherwise be surplus or unused. Or it may be done at some frequency and with some combination of equipment between these two extremes.

Agricultural engineers and farmers are working out the mechanical possibilities, equipment sizes, and machine-use methods which will lower operating costs for various farm jobs, with due regard for variations in economic, geographic, biologic, and personal factors which influence operating costs on individual farms.

AGRICULTURAL ENGINEERING

VOL 21, NO 2 EDITORIALS FEBRUARY 1940

Farm Expenses and Agricultural Engineering

RECENT estimates credited to the U. S. Department of Agriculture on how the farm income of the United States is spent, indicate in some measure the extent of the economic field for agricultural engineering activity.

Taxes, interest, rent to nonfarmer landlords, and wages are segregated as one group of operating expenditures taking 27.9 cents of the farm income dollar. Additional direct operating expenditures take 29.5 cents, and family living expenditures the remaining 42.6 cents.

Of the direct operating expenditure of 29.5 cents, at least 11.3 cents is spent on engineered farm operating equipment and materials, such as motor vehicles used in production; fuel, oil, and tires for such vehicles; farm machinery other than motor vehicles; service-building materials; and miscellaneous other operating equipment and supplies specially designed and produced for farm use.

The estimates were based on a farm income of $8,000,000,000 per year. On this basis the annual farm operating equipment and supply bill is $904,000,000. Relative to this volume of business, agricultural engineers are probably better qualified than anyone else to improve the equipment and supplies involved, from the standpoint of use requirements. In other words, agricultural engineers can tell the producers in engineering language what qualities such equipment and supplies should have to give greatest value in farm use. In many cases agricultural engineers can go further and show how these qualities can be provided in design and materials which are practicable from production, sales, and service standpoints. Manufacturers want this viewpoint in order to improve their products, service, and competitive position.

Building materials for the farm residence use 1.3 cents of the dollar and electricity for the residence 0.5 cents. This adds up to another $144,000,000 per year on which agricultural engineering considerations directly influence the value the producer and seller can give to the farmer customer. Together with the previous figure, this means that agricultural engineers can help manufacturers individually to qualify for a share of more than a billion dollars worth of annual farm business in engineered products.

A related job of agricultural engineers is to help farmers get maximum value from this same billion dollars of expenditure. Engineering principles are involved in the choice, use, care, and maintenance of the equipment and materials purchased. The principles need not only to be developed and stated, but their application to a wide range of variations in individual farm conditions needs to be worked out and explained, in order that the potential value built into the engineered equipment and materials purchased by farmers at the cost of more than a billion dollars may be realized in farm use.

Some other farm expense factors are also directly influenced by the way this billion dollars is spent and the use made of the purchases. Cash wages may be saved, feed values increased and wastes reduced, fertilizer used more effectively, improved stands obtained from less seed, and service costs reduced. These items represent another 19.5 cents of the farm expense dollar, or a total of $1,560,000,000. Together with equipment and material cost, this gives $2,608,000,000 of annual farm expenditure in which agricultural engineering is a direct factor from the standpoint of the farmer getting full value for his money.

Other farm expense items might be influenced less directly by agricultural engineering services. For example, the cost of medical services, a $200,000,000 item, might be reduced by better lighting.

The figures given are based on recent recorded volume and distribution of the farm income. Agricultural engineers are a factor in maintaining this income, through sound soil and water conservation practices, for example. They may likewise be a factor in increasing it by helping farmers to increase their capacity for economic service in farm production. New crops, reduced waste, and processing operations to put farm products more nearly in condition for consumer use are cases in point.

As to influencing the distribution of actual and potential farm expenditures, farm housing furnishes an example. Many agricultural engineers believe that farmers could advantageously spend more for better housing. They are encouraging this by showing farmers not only why, but how to make the most of whatever they may be able to spend to improve their housing.

In economic terms, the objective of agricultural engineers is not to reduce farm spending to the irreducible minimum, but to help farmers increase their earning capacity and to get maximum value and satisfaction from more than two billion dollars per year at their present rate of spending.

Balanced Agricultural Research

IN A recent statement before the congressional subcommittee on farm chemurgy, L. F. Livingston made an apparently good point in urging that the four regional laboratories of the U. S. Department of Agriculture should not be limited to a study of surplus farm products, but should be free to study and develop possible industrial applications of anything that is or might be grown on the farm.

Surplus farm products offer an attractive starting point in that they represent an unsatisfactory *status quo* in balance between production and consumption. They have proven fairly well adapted to production under climatic and soil conditions which exist in certain parts of the United States, and to farm production methods and equipment. They have been improved by breeding for efficient production. The obvious weakness is insufficient use at the price for which farmers can afford to produce these commodities, and the obvious remedies are new uses and lower production, handling, and processing costs.

The present *status quo*, however, does not necessarily represent the ultimate in the biological foundation of farm production. It does not preclude the possibility of finding or developing new crops, species, breeds, and varieties for effective use of land and other farm production facilities to produce new and valuable organic compounds; higher qual-

ity or new combinations of qualities in familiar organic compounds; or established market commodities at lower costs which would stimulate use, increase volume demand, and provide a satisfactory margin of farm profit. There is also the possibility of producing here, economically, some farm commodities which have previously been given an uneconomic joyride from foreign countries simply because American farmers have not yet succeeded in meeting our domestic market demand for all the farm products which our soil and climate would enable them to produce.

Development of these possibilities by research in the U. S. Department of Agriculture is consistent with its policy of basic and applied science research based on a long-range view of the interests of American farmers. The implied research in agricultural chemistry and agricultural engineering is a logical and necessary step toward profitable farm application of much of the biological knowledge gained by the research of the Department's plant explorers and other biological scientists.

Agricultural research begins to pay a return on the investment only when farmers actually begin to render increased economic and social service by reason of applying the results of research; in other words, using the improved biological materials, operating practices, and mechanical and structural operating equipment made possible by research. Agriculture's research problem is not only to determine what plants and animals can be produced in the United States, their relative productivity, the conditions under which they are most productive, and the possibility of increasing their productivity by breeding and by control of pests and diseases. This valuable knowledge will be applied only after agricultural engineering and related research has shown where and how it can be economically applied in farm practice, considering operating cost and market demand; and as research in agricultural chemistry expands market demand by developing the full usefulness of present and potential farm-produced organic chemicals and derivative products, for both food and nonfood purposes.

No advocate of government economy would say that, when Uncle Sam constructs a new building, the roof should be left off because it costs too much. Like the roof of a building, research in agricultural chemistry and agricultural engineering is a vital part of the whole structure for agricultural research. Let the research structure be of whatever size may seem best, all things considered, but let it be technically complete and well balanced in order that it may be a sound investment for effective work in the interests of agriculture.

Design of Agricultural Equipment

ENGINEERING design implies the embodiment of scientific principles in the shaping and combination of materials to meet specific use requirements predicated on economic or social considerations.

Two variations of emphasis on the knowledge required for effective design have developed within engineering. Each has its merits for certain fields of application.

In what are known as the basic branches of engineering, major emphasis is placed on mastery of certain classes of scientific knowledge and engineering method for application as indicated by self-evident or clearly defined use requirements for the object to be designed. This emphasis does not exclude engineering attention to use requirements but presupposes that sufficient knowledge thereof can be obtained by the engineer by observation or from others, without he himself being intimately familiar with the industry or other environment in which the design is to be used. In many cases this is true.

In what are classed as the industrial branches of engineering, major emphasis is placed on intimate knowledge of the industry because its equipment use requirements have proven so specialized, complex, and interrelated as to preclude adequate understanding by an engineer not intimately familiar with the industry, without a prohibitive amount of specialized study. Furthermore, the industry may be so organized as to require engineering services involving several of the basic branches of engineering technology and of specialized technology and engineering data not common to the usual applications of any of the basic branches of engineering. And it may be operated predominantly by men who are not engineers and not equipped to explain their engineering requirements to persons not familiar with the industry, or to see for themselves the opportunities in their industry for profitable use of engineering technology. These conditions do not minimize the importance of sound basic engineering, but they do mean that an engineer intimately familiar with the industry and well grounded in basic engineering may design equipment for it more effectively than some engineer equally well grounded in basic engineering and more highly trained and experienced in some branch of engineering technology, but not familiar with the industry in question.

No question should arise as to which direction of specialization is more important or valuable. There is plenty of opportunity for both.

Agriculture is one of several industries in which complicated specialized equipment use requirements have resulted in the development of a specialized branch of engineering. Responses of crops, livestock, and pests to environmental influences, soil factors, water as a plant requirement, personal factors, the organization of agriculture and its combination of production and living, the character of its products and markets, and geographic location and climate all are variables influencing equipment use requirements. There are numerous instances of physically sound designs in farm machinery, farm buildings, and drainage and irrigation projects which have failed to meet one or more use requirements in a specific situation or in enough situations to succeed. The design of farm equipment is primarily an agricultural engineering job.

When an agricultural engineering design problem is of sufficient importance and involves complicated problems of engineering technology sufficient to justify the attention of an aggregation of engineering talent, highly trained specialists in the basic branches of engineering technology can often be of great help in working out refinements of engineering technique to meet use requirements specified by agricultural engineers. In other cases it is necessary for agricultural engineers not only to define use requirements but to meet them with the best design technology at their command. Where biological factors are involved it often happens that even agricultural engineers, with their knowledge of farmers and farm practice, have to work in close cooperation with the biologists to accurately define use requirements.

Understanding of agriculture is important to agricultural engineering design from the standpoint of establishing objectives, and basic engineering is the technology with which those objectives can be achieved. Together they can give and are giving farmers continually improved facilities for working and living. Design is an important function of agricultural engineers.

The Structural Application of Glue in Framing Farm Buildings

By Henry Giese
FELLOW A.S.A.E.

A STUDY of losses to farm buildings because of windstorms in Iowa and an inspection of many buildings still in service but in poor structural condition indicate that Iowa farmers pay a large annual tribute to poor construction methods. Experiences in Missouri as reported by Wooley[15]* show further that poor construction is not peculiar to Iowa but may be observed in other states. In comparing structures alike in kind but varying in structural excellence, it is apparent that small savings in original cost, when made at a sacrifice of elements essential for structural stability, are accompanied by an acceleration in the rate of depreciation far out of proportion to the economies effected.

Because of the many widely scattered farm units, and the relatively small investment in each, the problems of structural efficiency and details making for economy of materials and labor have received too little systematic attention. The economic significance of structural stability has not been fully realized and "first cost" has been the pea before the eye which, because of its proximity, obscures the sun of "annual cost." The farmer is not able to solve these problems alone. Preoccupied with many other complex responsibilities which occur with greater frequency, he cannot be expected to become skilled in construction. As society has imposed no minimum standards by building codes or required inspections, and professional men have not found the planning of farm buildings profitable, the farmer does not find at hand the ready help he requires. In too many cases he does not seek help until the job is under way and he is in trouble. That he has done so well under these adverse circumstances is surprising.

Publicly supported institutions have given the matter considerable thought and have over a period of years furnished a large number of plans. It takes considerable temerity, however, to presume that the plans, which we of these institutions have furnished, specify correct structural practice, or that we have influenced farm construction to any appreciable extent.

Wood, which is still the principal structural material on the farm, has numerous qualities which have kept it first. It can be grown as a crop without depleting natural resources and is easily fabricated. The latter may actually be a handicap. If we commonly believe that anyone can fabricate wood, are we not likely to entrust its use to the semi-

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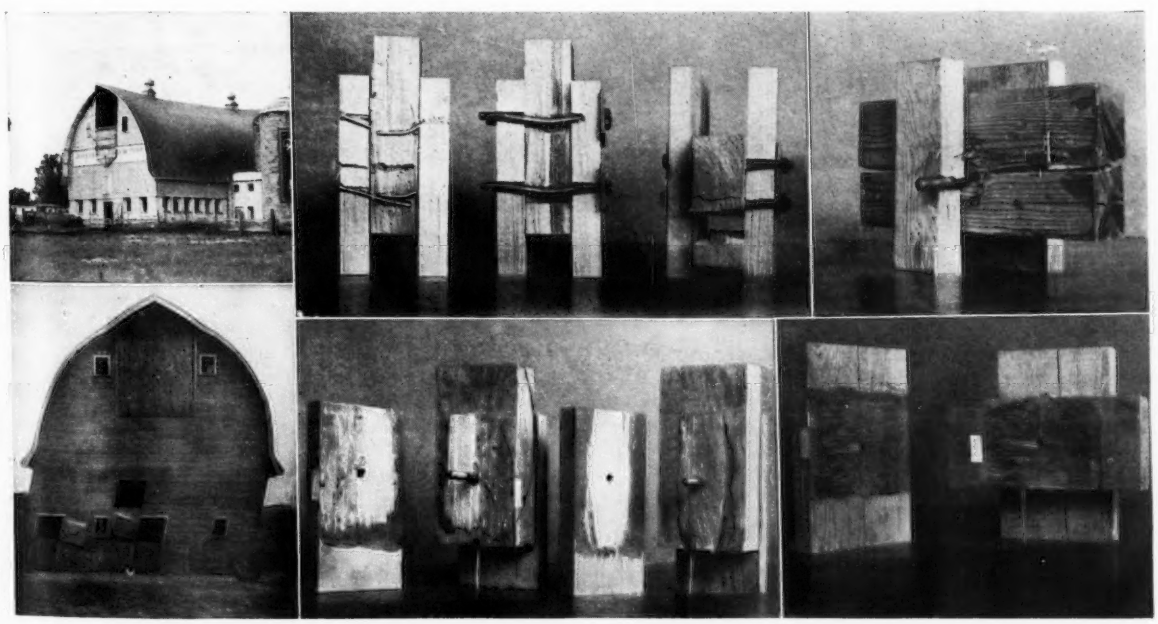
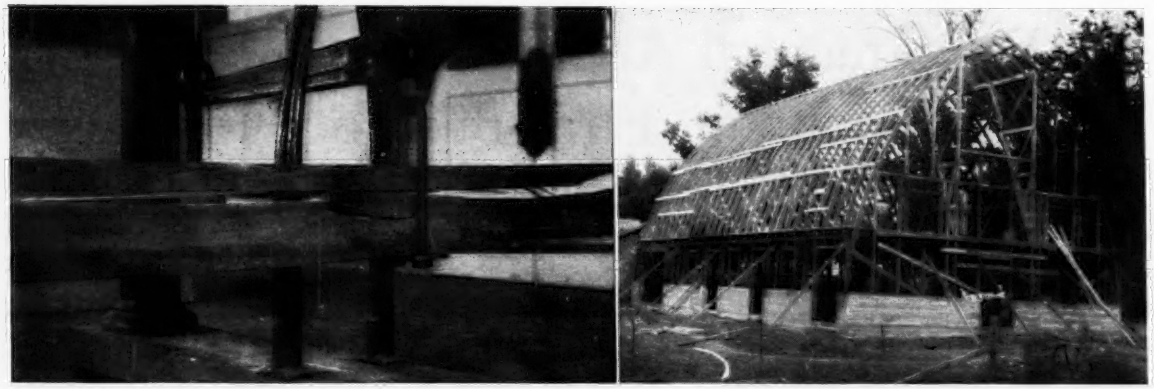
Presented before Farm Structures Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 6, 1939. Journal Paper No. J-716 of the Iowa Agricultural Experiment Station, Projects 23 and 563. The author is professor of agricultural engineering, Iowa State College.

*Superscript figures refer to literature cited at the end of Mr. Giese's paper.



JOINT FAILURES IN CONSTRUCTION AND TEST SPECIMENS

(Upper left) Slipping of laminations causes sagging of bent-rafter roof. (Lower left) Yielding of nail joints permits deformation of beam. (Upper center) Nailed and bolted joints showing character of failure. (Upper right) Failure of toothed-ring connector joint. (Lower center) Glue joint failures, load applied parallel to grain. (Lower right) Glue joint failure, load applied perpendicular to the grain of the center member



INFLUENCE OF GLUE ON STRUCTURAL PROPERTIES

(Left) Elastic properties of laminated beams differ from those of solid beams. (Right) Glue between laminations adds stiffness to rafters

unskilled and pay a penalty in poor construction greater than the expected gains? Wood is strong per unit of weight, but nature designed the character, distribution, and fastening of its fibers for a tree, a cantilever beam extending toward the sky. It therefore presents problems when used for other purposes. Lumber is comparatively soft and spongy and requires a large bearing area when used for structural members, especially when the loads are applied perpendicular to the direction of the grain.

For years nails have been the most common fastenings used in farm buildings. Nails are easily fabricated, relatively cheap, and are easily placed with little labor. For many purposes nails are satisfactory and will doubtless be used for a long time, but they present too little bearing surface to make possible a joint in a structural member comparable in strength to the other portions. When placed in shear, a nail joint begins to yield under a small load, crushes a few fibers in the adjoining surfaces, and the nail bends. Even if a sufficient number could be applied, without splitting the member, a vibrating load would loosen them and reduce the effectiveness of the joint. A reduction in the moisture content of the wood loosens nails and further reduces their effectiveness. Bolts offer the possibility of increasing the bearing area, and also the effectiveness further from the plane of contact. Bolts, however, necessitate bored holes and, in addition to being more expensive, have required so much labor for installation that their use has not been extensive. Timber connectors recently introduced into this country from Europe further increase the area of contact in a shear joint and should find many applications in farm structures.

Some attention has been given in recent years to the possible application of glue for this purpose. It is my desire to review the studies undertaken at the Iowa Agricultural Experiment Station during the past ten years in the use of glue in farm building construction. Glue appeared to offer the possible advantage of being able to increase the area of contact at the joint to almost any desired amount. By the use of gussets there was also the probability of success in fixed beams and rigid construction.

Casein glues are low in cost and, being mixed with cold water, are easily applied. Some now available are self-bonding and require little pressure for a successful joint. On the other hand, just how much dependence could be placed upon the use of glue was not known. Just how good could one expect a farm-made joint to be, and what effect would exposure to moisture, ammonia fumes in barns, etc., have upon the effective life? We have frequently faced the belief that glue would deteriorate over a period of time, leaving a joint worthless or less effective than if formed in the usual manner.

Years ago, while on field trips over Iowa, I observed that gothic roofed barns, quite popular with the farmer, often were sagging and not structurally satisfactory when built with bent rafters, because the nails used did not prevent the laminations from slipping, one past the other. The savings in bent laminated rafters over the older segmentally sawed rafter were lost, and stiffness, not strength, appeared to be the limiting factor. After some efforts to provide structural stability in other ways, the general conclusion was reached that here was a place where glue could serve eminently. There appeared, also, the further advantage of using bent rafters as a test for glue because, if the glue did fail in time, the rafters would still be no worse than those in common use. Part of this earlier work was reported by Giese and Anderson[5] and Giese and Clark[6]. The original intention in these studies was to use glue simply to carry the horizontal shear, a relatively small factor in a long barn rafter. Laminated beams were made both with and without glue. The glue was applied in a manner which might be expected to be used by farmers and farm carpenters in a strip down the center of the joint only with no pressure other than that furnished by the nails and in some cases nails and bolts. Bending tests were made on beams 12 ft long and tested on a 10-ft gage length. The tests showed that glue, applied in even this apparently careless manner, was effective in carrying the shearing stresses involved and the test beams compared favorably with solid members.

As a further test, the damaged portions of the beams were removed, and after one year the remaining pieces, now 5 ft long, were tested on a 4-ft gage length.

The results of this test were essentially the same as in the previous test. In the shorter beams, shear was a larger factor and several failed in this respect. The lowest unit shear calculated was 155.5 lb per sq in, considering the total width of the strip, whereas the glue covered only about one-half of the width.

The unbroken ends of the beams from this test were again shortened to remove any defective portions and stored in an unheated shed. In 1939, seven years after fabrication, Martin[9] placed them in the testing machine once more and tested as very short beams. Since the investigation was concerned primarily with the shearing strength of glue, the beams were not loaded to destruction. When 5100 lb, the

limit for the scale on the testing device, was reached, the maximum horizontal shearing stresses developed were 264 lb per sq in at the neutral surface for the beams composed of five 1x4-in laminations, and 293 lb per sq in at the neutral surface for the six 1x3-in laminations. Of the ten specimens tested, only four showed signs of failure, and these in the wood rather than in the glue.

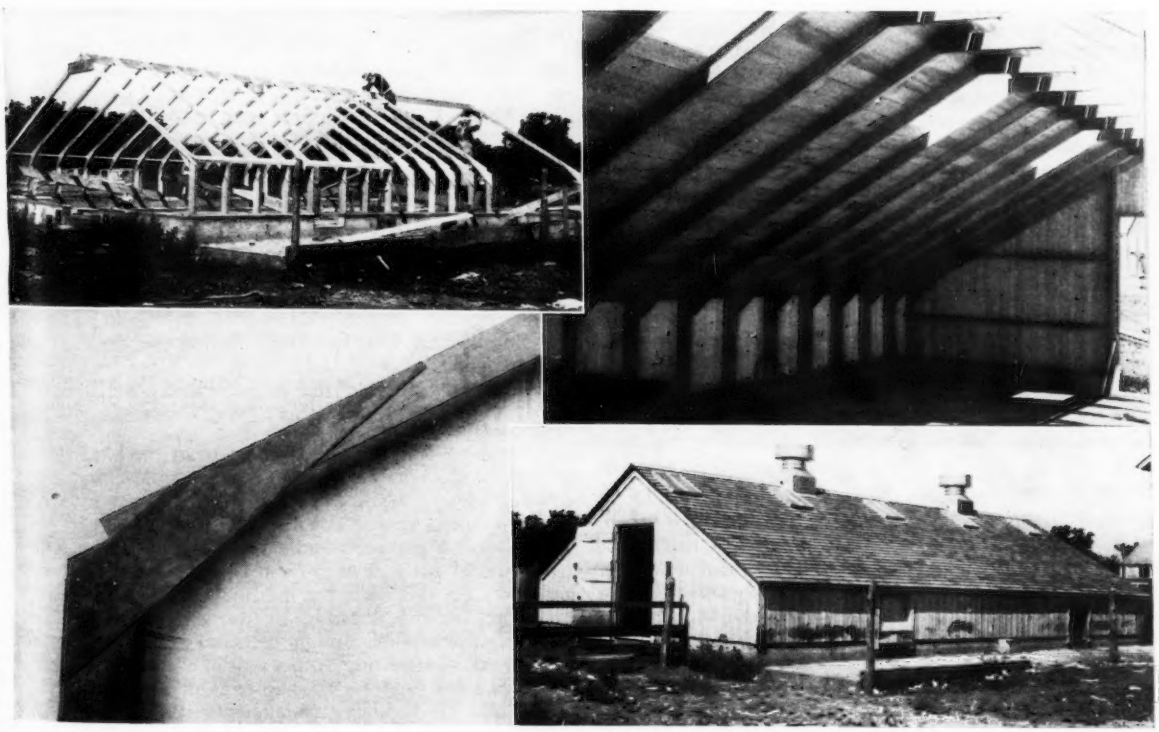
Two pure shear tests were also made, one on the beam with six 1x3-in laminations and one on the five 1x4-in laminations. In the first a load of 23,040 lb produced failure, which distributed over 55 sq in means 419 lb per sq in over the gross area. In the second case, a load of 24,100 lb produced shear failure, with the shear distributed over 72.6 sq in, or an average shear of 322 lb per sq in. In each case an inspection of the joint failure showed that the area over which the glue was effective was only about one-half the total area of the surface. These shear values are much higher than will ever be encountered in barn rafters from 30 to 36 ft in length and with a depth of approximately 5½ in. No apparent deterioration had taken place after a period of years. While nine years represent the extent of our personal observations, glued structures have been in use in Europe for a much longer period. Wilson[13] after inspecting about forty structures employing laminated glued construction in Germany, Switzerland, Norway, Denmark, and Sweden, which varied in date of erection from 1911 to 1936, and some of which were not adequately protected from the weather, reports as follows:

"Mr. Chas. Chopard (of the former firm of Texner and Chopard, Zurich) who has probably had longer experience with 'Hetzer' construction than anyone now living, is of the opinion that casein glue is as durable as wood under damp conditions. This opinion, of course, relates to native Swiss conifers not subjected to preservative treatment.

"The instances I have described (Adolfsberg bridge and locomotive shop at Bern) are by far the worst cases of deterioration I have observed. Some checking and opening of glue joints was evident in roof members that had obviously been subjected to very dry conditions, as well as where the construction had been subject to alternate wetting and drying, as in end frames of some of the passenger platform structures. This, however, was no worse than would be expected in single piece members under the same conditions and not serious enough to endanger the structural integrity of the structures."

From these observations and in consideration of the fact that glues have been and are still being improved in quality, it seems that this type of construction need not be discounted because of durability. On the other hand, unless exposed to unusual hazards, such as fumes from stables, the effect of which is not now known, one may expect such construction to give long serviceable life.

Martin[9] also made a number of transverse tests on commercial glued laminated barn rafters about four years old to determine their mechanical properties. These rafters contained neither nails nor bolts. As the joints were not scarfed and their location was an important factor in strength and stiffness, test beams were selected with joints in critical places. His tests showed that the horizontal shearing strength of glue exceeds the shearing strength of wood. The location of joints is very important, especially in the outer members. They should not be located at parts of the rafter which may be subjected to large bending moments. If the



CONSTRUCTION OF RIGID FRAME HOG HOUSE

(Upper left) Erecting framework. (Upper right) Interior, showing freedom from posts and braces. (Lower left) Detail of joint between stud and rafter. (Lower right) Completed structure

selection of the material does not make this possible, the ends of the pieces should be scarfed.

Pickard [10], in a study of the braced rafter roof, investigated the possibilities of using glue at the joints. In order to simulate actual farm conditions as closely as possible, he made glue joints using 2x6s and 2x8s with one bolt in each case and using not only flat members but also pieces appreciably warped. Double shear tests were made with the load applied parallel to the grain of all members and also perpendicular to the grain of the center member. One of the features of a glued joint, as shown by his work as well as others mentioned here, is the fact that it does not slip or yield under comparatively small loads as do other methods of fastening. Consequently, glueing makes a much more rigid joint. The glued joint performed particularly well when the load was applied perpendicular to the grain, and, for the most part, failure occurred in the wood fiber rather than in the glue joint. Even though the members were appreciably warped, the results compared favorably with other methods of fastening. Because of fibers tearing out, however, a joint with forces applied perpendicular to the grain in one piece is only about one-third as strong as if the force were applied parallel to the grain.

Another application of glue was made in the construction of a plywood poultry brooder house[2,3,7]. The effectiveness of a poultry brooder house which will make possible the keeping of chicks on disease-free ground, depends largely upon the ease with which it can be moved from place to place. A brooder house of plywood with the sheets glued to bent laminated glued rafters was much lighter than the conventional type of house, and hence more easily moved. It was also remarkably rigid and substantial when compared with conventional types.

Another recent application in the use of glue has been to build a low structure suitable for a hog house or lamb shed where only a low side wall is required. The construction of this house is shown in the last four figures of this paper. A gusset plate forms a knee brace, joining a 2x4-in, 12-ft rafter to a 2x6-in, 30-in stud. These combination studs and rafters are prefabricated. No interior supports are necessary, and the resulting structure is exceptionally rigid. A minimum of materials and labor is required. Self-bonding glue is used, and nails hold the individual pieces in place until the glue hardens.

In closing, I would say that although glue has been used extensively in Europe and in some other structural fields in this country, I know of little use having been made of it in farm structures. Glue possesses qualities which make it admirably suited to many farm applications. The principal benefit from its use lies in the possibility of increasing the bearing area at joints to almost any desired size, thus making possible the stressing of intermediate members to nearer their capacity. The greatest structural problem in the use of wood is the development of techniques for fastening structural members which can and will be used by rural carpenters. While we have been hesitant in making recommendations because of difficulties in fabrication, we do know that satisfactory jobs have been accomplished. Enough experience has been gained that we are confident work can be accomplished which is lasting and satisfactory.

If Gothic rafters are nailed also, or perhaps fastened with a few bolts, the use of glue cannot be questioned, because even if serious deterioration of the glue line occurred, it would still be amply strong to carry the small amount of horizontal shear placed upon it. I know of no failures among the large number of barns using commercial rafters which carefully fabricated under high pressure, contain neither nails or bolts. I feel sure, however, that we shall see a growing use of glue in structural members as the possibilities become better known and rural carpenters learn its use. Laminated bent glued constructions are finding use in cribs, silos, pavilions, 4-H club exhibition buildings, and auditoriums, field houses, and doubtless many other places.

Rigid construction, using glued joints with solid members, is equally promising and will doubtless include machine sheds, gambrel-roof construction, one-story dairy barns, farm shops, etc. When the use is extended to these and other fields, we shall attain economies through the more effective use of materials and lower depreciation through longer structural life.

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[15]Wooley, J. C. Farm building studies in Northwest Missouri. Missouri Agr. Exp. Sta. Research Bulletin 218, 1934.

Investment per Cow for Housing

FROM the Dairy Husbandry Department of the Nebraska College of Agriculture, we learn that housing costs should not exceed 10 per cent of the total cost of keeping a cow and that less would be very desirable. From the extention service of the same Department we have a summary of milk production costs for one year (August 1932 to August 1933) for 3,651 cows in Nebraska averaging 8,789 lb of milk containing 344 lb of butter fat.

Assuming $84.48 to be 90 per cent of the total annual production costs per cow, the 10 per cent annual charge per cow for housing would amount to $9.39. If we break this annual housing charge down into interest at 5 per cent, depreciation 5 per cent, and taxes 1 per cent, the $9.39 represents 11 per cent of the structure investment per average cow. On this basis the maximum allowable structure investment per cow would be $85.36. For better than average herds this maximum might be raised to $100.00 or even to $125.00. Considering 10 per cent of the cost of keeping a cow as a top limit for housing costs, it would seem that if the total structure investment per average good cow exceeds $85.36, the soundness of farm management in this respect would be questionable.—*From a contribution by F. D. Yung to the report of the A.S.A.E. Committee on Dairy Structures and Equipment for 1938-39.*

Code Regulations for the Electric Fence

By F. W. Duffee
FELLOW A.S.A.E.

THE increasing popularity of the electric fence, together with an increasing number of fatalities in both humans and animals, has led to legislation and codes regulating its construction, operation, and installation. Previous to the development of the electric fence, the prime purpose of electric codes has been to protect humans and animals against shock and to prevent fire hazards. The very principle of the electric fence is contrary to the whole philosophy of codes up to this time, because here we do stretch an exposed energized wire across fields for the express purpose of giving a shock to animals should they undertake to cross the path of the wire.

HISTORY OF ELECTRIC FENCE REGULATIONS

So far as we know, the first formal regulations relative to electric fences were issued by the Oregon State bureau of labor on December 10, 1936.

In 1937 the Wisconsin legislature passed a law authorizing the state industrial commission to set up rules to regulate the construction, specifications, and use of electric fences. The orders of the commission became effective October 6, 1938.

In the winter of 1937-38, the Technical Subcommittee on Electric Fences of the National Electric Safety Code (N.E.S.C.) was formulated. Official notice of the formation of this subcommittee was given February 16, 1938.

The Underwriters' Laboratories received their first application for an investigation of electric fence controllers in October 1936. The first edition of the Underwriters' Laboratories standard is dated September 1939.

I believe there have been some orders in California prohibiting the use of certain types of fences, and some other states have taken at least informal action, but I believe that Oregon and Wisconsin are the only states which have definite and comprehensive rules and regulations on the subject at the present time.

The Oregon rules, while representing a very definite step forward, are nevertheless brief, so I shall confine this discussion largely to the other three codes, namely, the Wisconsin law, the National Electric Safety Code (N.E.S.C.) on electric fences, and the Underwriters' Laboratories standard for electric fences.

The Wisconsin code is a part of the statutes of the state of Wisconsin and requires that the units must be approved by the state industrial commission before they can be sold in the state. It also makes special provisions for units that were in use at the time the orders went into effect, and carries some provisions relative to the installation and use of electric fence controllers. This law provides penalties for violation. The enforcement is in the hands of the Wisconsin Industrial Commission. I believe the Oregon orders are similarly enforced by a state commission.

The N.E.S.C. is a complete and comprehensive code pertaining to all phases of the use of electricity as it applies to safety. This code is sponsored by the U. S. Bureau of Standards, and Dr. Morton G. Lloyd of the Bureau is in charge. This code serves as a guide, particularly as regards central station and line construction and operation. It has been adopted in its entirety by some states, and when so adopted becomes law.

The Underwriters' approval or listing of any unit merely represents a badge of approval by this private organization. While it is true that Underwriters' approved units are acceptable in whole or in part under the law in most states, nevertheless the Underwriters' approval has no basic legal standing. Regulatory and law-enforcing bodies may or may not accept the Underwriters' approved equipment.

Major factors included in a code of law covering electric fence controllers are about as follows:

1. Designation of a regulatory and enforcing body and outlining a procedure for obtaining approval
2. Specify penalties for lack of compliance
3. Provide specifications for the controllers covering the following major points:
   (a) Define current and time limitations for various types of controllers
   (b) Provide tests that will demonstrate the integrity of the controller through a range of probable operating conditions such as temperature, moisture, etc.
   (c) Specify construction features as related to safety, such as transformer types, construction, insulation requirements, etc.
4. It should provide some limitations relative to the installation and use of the controller, such as prohibiting the use of two controllers on any particular fence.

UNIFORMITY OF CODES DESIRABLE

Naturally it would be highly desirable to have the codes uniform, at least as regards the major specifications and the details and requirements of construction, but unfortunately they do not.

The Wisconsin and the N.E.S.C. codes are essentially the same, the one important exception being that the Wisconsin orders prohibit the so-called "continuous" alternating-current (a-c) controller where there is continuous potential on the fence wire at all times, whereas the N.E.S.C. includes this type. I should like to say here, however, that the Wisconsin advisory committee did recommend a continuous type a-c controller in their report.

The Underwriters' standard for electric fences differs primarily from the above-mentioned codes in that it permits greater current output by the controller and longer "on" periods. Further, it provides for a relation between current and time for the a-c type so that the current can be increased as the "on" period is decreased.

A brief description of types of controllers is in order,

Presented before the Rural Electric Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 7, 1939. The author is professor and head of the agricultural engineering department at the University of Wisconsin. Mr. Duffee is chairman, Advisory Committee on Electric Fences, Wisconsin Industrial Commission; chairman, Technical Sub-committee on Electric Fences, National Electric Safety Code; chairman, A.S.A.E. Committee on Electric Fences.

so that we may better understand the differences in specifications. There are four types, namely, (1) inductive-discharge, (2) capacity-discharge, (3) intermittent alternating current, and (4) continuous alternating current.

The inductive-discharge type is primarily the battery type unit and consists essentially of breaker points and an induction coil. This type may be energized from 110-volt a-c service through the medium of a converter.

The capacity-discharge type energizes the fence wire from the discharge of a condenser.

The a-c intermittent type energizes the fence wire from 110-volt a-c service through a current-limiting transformer. An oscillating motor or positive make-and-break mechanism of some kind (usually in the primary circuit) permits energizing the wire for "on" periods of from 0.1 to 0.2 sec with "off" periods between the shock periods of not less than 0.9 sec. The transformers generally used deliver a practically normal 60-cycle a-c wave form. The fence is thus energized intermittently from the secondary side of the transformer.

The a-c continuous type in its simplest form consists merely of a transformer of suitable type which delivers potential to the fence wire continuously.

The Wisconsin and N.E.S.C. codes provide an "on" period not to exceed 0.1 sec for all types. The a-c intermittent type shall have a frequency of not over 60 impulses per minute; and the inductive and capacity-discharge types shall provide "off" periods between shock periods of not less than 0.75 sec.

The Underwriters' standard permits an "on" period of 0.2 sec with an "off" period of not less than 0.9 sec.

Speaking only for myself, I feel disposed at this time to favor an "on" period limit of 0.2 sec as specified in the Underwriters' order. However, if this change were made in the Wisconsin and N.E.S.C. codes some changes of current limitations probably should be made.

With the inductive and capacity-discharge types of controllers the current limitation is expressed in milliampere-seconds, or millicoulombs. In the intermittent and continuous a-c types the current limitations are expressed in milliamperes (root mean square [rms]).

Obviously the principal objective of all electric fence regulations is to so limit the current that the fence will be safe, not only to humans but to animals also.

As the current limitations constitute the principal difference between the Underwriters' standards on the one hand and the N.E.S.C. and Wisconsin orders on the other, I shall discuss these differences briefly and point out some of the reasons for the differences. I do want to emphasize at this point that a great deal of effort was put forth to bring all of these into conformity, but this has been impossible thus far.

The N.E.S.C. and the Wisconsin orders allow 3 ma-sec (milliampere-seconds) for the inductive and capacity-discharge types for each "on" or shock period, and each shock period is limited to 0.1 sec. Underwriters' allow 4 ma-sec for an "on" period of from 0.1 to 0.2 sec. For an "on" period of less than 0.1 sec a curve is provided (Table 1 and Fig. 2).

N.E.S.C. and the Wisconsin orders allow a flat maximum of 25 ma (rms) with an "on" period not to exceed 0.1 sec for the intermittent a-c type. The Underwriters' in general allow greater quantities, with a further difference that the current may be increased as the "on" time is reduced. Specifically, a curve is provided (Fig. 1). Table 1 will give an idea of its range.

TABLE 1

"On" time in seconds	Maximum permissible current in milliamperes (rms)
0.2	5
0.1	40
0.05	57.5
0.0275	65

It will be observed that the Underwriters' standard permits 30 per cent more current for the inductive-discharge type and 60 per cent more current for the intermittent a-c type for an "on" period of 0.1 sec than does the N.E.S.C. or the Wisconsin orders. Also Underwriters' permit a maximum amperage of 65 ma for an "on" period of 0.0275 sec; whereas the N.E.S.C. and Wisconsin orders provide for a maximum flat 25 ma for any period of "on" time up to 0.1

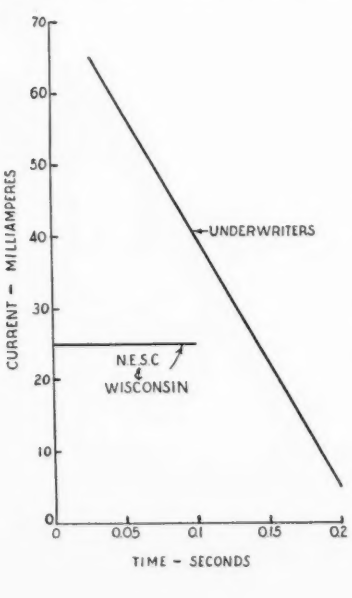

FIG. 1 (LEFT) CURRENT-TIME LIMITATIONS FOR 110-VOLT A-C TYPE CONTROLLERS

The National Electric Safety Code and the Wisconsin code provide a fixed current limitation of 25 milliamperes, with an "on" period of not to exceed 0.1 sec. The Underwriters' standard allows for an "on" period up to 0.2 sec; this standard also permits higher current values for shorter periods of "on" time

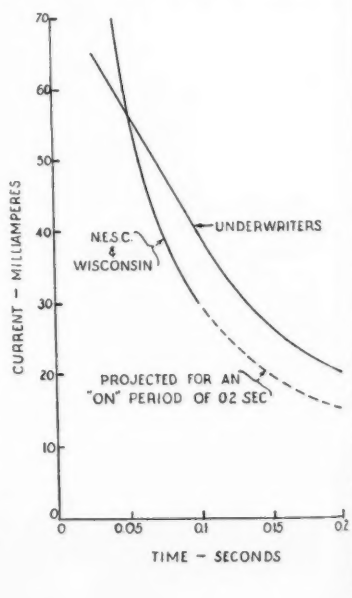

FIG. 2 (RIGHT) CURRENT-TIME LIMITATIONS FOR INDUCTIVE AND DISCHARGE CONTROLLERS

All three codes follow much the same general principles, except that the Underwriters' standard permits larger quantities for the longer periods of "on" time. The members of the Electric Fence Committee of the N.E.S.C. maintain that the character of the shock from an inductive and condenser discharge type controller is quite different from that of the conventional a-c type of controller and this is substantiated by a study of oscillograms taken from the different types

sec. This is the most critical difference, as it is the vital factor in determining whether or not a unit is safe.

Unfortunately there is no research data that are directly applicable to this work. However, there are a great deal of data that bear on the subject which, it is believed, form the basis for reasonable assumptions as to what may constitute a safe fence.

In order to determine which of the above specifications may be best to follow, let us investigate the authorities back of each. The Technical Subcommittee on Electric Fences*, Part III, of the National Electric Safety Code includes many of the leading authorities in the world today on the subject of the effect of electric shock upon humans and animals. We emphasize the point that there are several medical men on the committee, as well as electrical engineers and others. The Wisconsin Advisory Committee on Electric Fences also consisted of a number of men of national reputation in the field of safety regarding electricity, such as E. E. Bennett, head, electrical engineering division, engineering college, University of Wisconsin; John E. Wise, electrical engineer and safety engineer, Wisconsin Industrial Commission; Royce E. Johnson, electrical engineer in charge of the standards laboratory, engineering college, University of Wisconsin; Ralph E. Purucker, electrical engineer, Wisconsin Public Service Commission; E. J. Kallevang, chief engineer, Wisconsin Power and Light Company.

EXPERIMENTAL BACKGROUND OF THE CODES

Many of these men have had a great deal of actual experience with the effects of electric shock on humans and animals, and have carried on extensive research work. On the other hand, the Underwriters' report and standard for electric fence controllers was prepared by an electrical engineer, almost entirely from library study, and the principal reference was a report, entitled "The Effect of Electric Shock on the Heart," by L. P. Ferris (Fellow A.I.E.E.), Bell Telephone Laboratories; B. G. King, Columbia University; P. W. Spence (Member A.I.E.E.), Bell Telephone Laboratories; H. B. Williams, M.D. (Member of American Physiological Society), Columbia University.

This report covers nine years of extensive research work in the college of physicians and surgeons of Columbia University, during which hundreds of head of livestock were killed under most careful observation so that this report should be a most excellent guide. The two leading members of the group conducting this research are members of the N.E.S.C. committee, so it could get the direct advice of these men. I should like to give you the reactions of some of these men to the Underwriters' Laboratories standards by quoting from their letters, which quotations are being made with the approval of the writers. I quote first from a joint letter from Williams, King, Ferris, and Spence directed to the assistant electrical engineer of the Underwriters' Laboratories dated October 11, 1939:

"We have read the section of your report dealing with allowable current which is largely based upon our tests, and we feel we would be derelict in our duty if we did not point out to you our belief that the use of our data to derive, as you have done, the minimum fibrillating current for a two-year-old child, is quite unjustified. In our letter to you of August 16, 1939, we stated, in answer to your question No. 3, that we did not have data on the relative sensitivity of fibrillation of a child and adult. We stated in our paper, 'The thresholds differ widely for different individuals of the same species.' If you will refer to Figs. 4 and 5 of our paper, it will be apparent that among the individuals of a single species, simple proportionality between body weight or heart weight and minimum fibrillating current does not exist. Had we believed it possible to draw such a conclusion from our data, we most assuredly would have done so in our own paper. Inasmuch as we might, through a misunderstanding, be deemed in a measure responsible for your derived minimum fibrillating current of a two-year-old child, we felt we should advise you that the undersigned disapprove such derivation."

DANGERS OF PROLONGED CONTACT

The next two quotations refer to the Toppenish accident. This involved the death of a 16-year-old boy who fell over a wire energized by a controller, which I understand had been approved under the Oregon regulations; however, investigation of this particular unit revealed that it delivered 49.2 ma with an "on" or "shock" period varying from 0.116 to 0.20 sec. The Oregon rules specify a maximum "on" period of 0.1 sec and maximum current of 45 ma.

Another letter from Williams, King, Ferris, and Spence was directed to the assistant electrical engineer of the Underwriters' Laboratories and dated December 7, 1939. (This letter did not come to the author's attention until after this paper was delivered.) I quote from this letter as follows:

"In the light of present information, we regard your proposed limits as hazardous, having in mind the conditions under which currents are to be used for electric fencing purposes. This is in spite of the fact that our paper does not indicate danger to the heart of a man until greater currents are reached.

"It appears to us that you are placing too much emphasis on the heart in setting your limit. Our experimental study was almost exclusively on the effect of shock on the heart by reason of the conditions which led to the study. These conditions are quite different from those presented by the electric fence which may give continuous or rapidly repeated shocks not contemplated in our tests. Under these 'fence conditions' effects which do not primarily involve the heart call for lower limits.

"In permitting any value of interrupted current which, if continuous, would not permit a victim to free himself from contact, it is vital that the interruptions, duration, and excess of current over the non-release threshold (for continuous shock) insure such release. We do not believe that the opportunity for a victim to release himself is equal for all points shown on your Graph 4, assuming 'off periods' of 0.9 sec.

"With present information, a safe limit for interrupted alternating current would be but little above the threshold of inability of a human victim to free himself from contact. Swiss researches, referred to in our paper, set such a threshold at 15 ma. There is no question but that a conscious victim would immediately attempt to free himself from accidental contact with an electric fence, but if he is so hurt that he fails to do so after the first few current pulses, his ability to free himself would become progressively less, and chances of a fatality higher. It is therefore important not to shock a victim to such an extent that he cannot immediately react to free himself.

"The Toppenish accident recorded in your report appears to be just such a case where the initial effect of an interrupted current of about 50 ma rendered the victim unable to free himself. Death

*The personnel of this subcommittee consists of H. J. Burton, safety engineer, Consumers Power Co.; A. B. Campbell, electrical engineer, Edison Electric Institute; W. B. Kouwenhoven, dean, school of engineering, Johns Hopkins University; Dr. D. R. Hooker, medical school, Johns Hopkins University; Gordon Thompson, electrical engineer, Electrical Testing Laboratories; L. P. Ferris, electrical engineer, Bell Telephone Laboratories; Dr. C. J. Wiggers, Western Reserve University; Dr. H. B. Williams, college of physicians and surgeons, Columbia University; R. G. Warner, United Illuminating Co. (formerly electrical engineer), Dunham Laboratory, Yale University; R. B. Shepard, electrical engineer, Underwriters' Laboratories; T. H. Bartilson, Division of Animal Husbandry, U. S. Department of Agriculture; F. W. Duffee (chairman), head of agricultural engineering department, University of Wisconsin. Dr. Morton G. Lloyd, U. S. Bureau of Standards, who is in charge of the entire work of the N.E.S.C., also collaborated in the preparation of this code and rendered much valuable assistance.

evidently was not due to ventricular fibrillation because the pulse was observed following the shock. Your Graph 4 permits even greater currents, though for somewhat shorter intervals, the proportional advantage of which from this standpoint we question."

Replying to an inquiry addressed by me to members of the N.E.S.C. Technical Subcommittee, L. P. Ferris writes as follows under date of October 13, 1939:

"My preference is to leave the specification as it now stands with a fixed current limit. I am not now willing to approve a higher limit than is contained in Part 6 of the National Electrical Safety Code adopted by the Technical Committee on April 5, 1939, namely, 25 rms milliamperes.

"Referring to the Underwriters' proposed limit indicated on Graph No. 4, which you enclosed, and which purports to represent the contact time versus allowable current for a two-year-old child, I am obliged to say that I know of no data which would justify drawing such a curve. Since receiving your letter, I have received from Mr. ..... the Underwriters' report on electric shock as it pertains to the electric fence, and this report explains how that graph was derived. It is largely based on the data secured in our experimental investigation at Columbia University. However, I do not believe that Mr. ..... is justified in such a derivation. He says at the bottom of page 28 of this report 'Although we have no data to indicate how the minimum fibrillating current varies in relation to body and heart weights or to age in a single species of animal, it seems safe to assume that a similar relationship may prevail.' Our data, which Mr. ..... uses extensively in his derivation of Graph No. 4, does, however, give information on this point, but it has been ignored by Mr. ..... That information is negative, and by that I mean Figs. 4 and 5 of our paper show that there is no correlation between body weight or heart weight of animals of a single species and minimum fibrillating current. In the face of such evidence I cannot understand how Mr. ..... can conclude it is safe to assume a simple proportional relationship to exist. Certainly, we were hoping to find something of the kind, but our data would not permit us to draw such a conclusion. Since Mr. ..... fundamental assumption is unjustified, it follows that Graphs Nos. 3 and 4 of his report have no sound foundation. I therefore cannot subscribe to the use of Graph No. 4 as a proper basis for current limits for electric fences. I do not believe our information on hand justifies a curve, and I am of the opinion that the values given by Graph No. 4 are too high even for an adult.

"Evidence in support of my belief that the Underwriters' Graph No. 4 permits too great currents is contained in the Underwriters' report itself. I refer to the account of the Toppenish accident. Apparently it is well established that a 16-year-old boy was killed by accidental contact with an electric fence, from which he could receive no more than 50 ma interrupted. This is indeed somewhat surprising, but I am afraid we must accept it as a fact. The contact was evidently prolonged a number of minutes, although it is difficult to understand why he did not free himself, or was not freed more promptly by his companions. From the account given in the Underwriters' report, it does not appear that death resulted from ventricular fibrillation, because it is stated that one of the boy's companions found a faint and irregular pulse after freeing the victim. During ventricular fibrillation no pulse can be detected. In our paper we have stated any currents that prevent voluntary control of the skeletal muscles are dangerous, because they might stop breathing, and if prolonged, asphyxial death would result. Apparently this happened from the continued repetition of a 50-ma shock for 5 min or more, showing the desirability of setting a lower limit of current (1) to increase the chances of a victim being able to free himself, and (2) diminishing the paralyzing effect of the current if he is unable to do so. . . . .

"I am not now willing to approve a value of 4 ma-sec as a limit for battery-operated controllers."

POSSIBILITY OF ASPHYXIA AS A FACTOR IN ELECTRIC FENCE SAFETY

All of the Underwriters' standards seem to be based on the possibility of death due to ventricular fibrillation; however, as a matter of fact, death due to asphyxia may be caused by a much lesser amount of current.

TABLE 2. ANALYSIS OF INDUCTIVE-DISCHARGE TYPE CONTROLLERS

Total number of units approved	73
Total number of *different* units (Several units are sold under more than one name.)	48
Average current output per "on" period (48 units)	1.3 ma-sec
Range in output—maximum output per "on" period	2.84 ma-sec
minimum output per "on" period	0.14 ma-sec
Number of (*different*) units having output greater than 2.5 ma-sec per "on" period	5
Number of (*different*) units having output of 2.0 to 2.5 ma-sec per "on" period	4
Number of (*different*) units having output of 1.0 to 2.0 ma-sec per "on" period	22
Number of (*different*) units having output of less than 1.0 ma-sec per "on" period	17

Quoting from a letter from Russell G. Warner, dated September 2, 1939:

"My preference is for the N.E.S.C. merely because the millicoulombs are less. I do not object to a definite 3-millicoulomb limit." (Refers to the a-c intermittent type.)

Quoting from a letter from Dean W. B. Kouwenhoven, dated September 14, 1939:

"I would prefer the 3-ma-sec value. Has not experience shown that this is sufficient to control animals?"

The members of the Wisconsin Advisory Committee were unanimous in establishing a 3-ma-sec limit for inductive and capacity-discharge types, and preferred to have the a-c interrupted type limited to a flat 25 ma (rms).

One of the principal reasons for limiting the current of the intermittent a-c type is based on the possibility of the unit being tampered with and the interrupter shorted, thus producing a continuous type of controller. It is feared that such tampering may occasionally occur regardless of how well the unit is designed to prevent it.

An intermittent controller designed to meet the Underwriters' standard and delivering, let us say, 50 ma (rms) for 0.07 sec would indeed be a dangerous piece of equipment if the interrupter were shorted out.

In the case of the Toppenish accident, a 16-year-old boy was killed by a unit delivering 49.2 ma of current for "on" periods of from 0.116 to 0.20 sec, or an average of just slightly more than twice as long an "on" period as allowed by Underwriters' for this current value.

There is some evidence indicating that a shock resulting from lower current for longer periods of time is more effective than a shock resulting from higher current for a short period of time. We cannot be specific regarding this as yet, but point out that a continuous type controller permitting a maximum of 10 ma (rms) is effective under a large variety of conditions.

The experience of Royce E. Johnson of the electrical standards laboratory, University of Wisconsin, is illuminating. He accidentally took the shock from a capacity-discharge type of controller which had a maximum output of about 5 ma-sec, although it is estimated that he did not get the full charge from the unit. The shock caused him to stagger backward to such an extent that the manufacturer of the unit who was present thought he was going to fall and ran around behind him to catch him. In this connection I wish to point out again that the Underwriters' standard permits up to 4 ma-sec for "on" periods from 0.1 to 0.2 sec.

The millicoulombs, however, are somewhat less for periods of time shorter than 0.1 sec.

Some complaints have been received relative to the effectiveness of controllers that have been approved under

TABLE 3. ANALYSIS OF CAPACITY-DISCHARGE TYPE CONTROLLERS

Total number of units approved	10
Total number of *different* units	3
Average current output per "on" period (2 units)	1.75 ma-sec
Minimum output per "on" period	1.2 ma-sec
Maximum output per "on" period	2.3 ma-sec

Only 10.4 per cent of all the inductive-discharge controllers deliver a shock in excess of 2.5 ma-sec, and none of the capacity-discharge type deliver this amount.

TABLE 4. ANALYSIS OF INTERMITTENT a-c TYPE CONTROLLERS

Total number of units approved	9
Total number of *different* units	9
Average current output (max. setting)	22.6 ma "on" time 0.054 sec
Minimum current output (max. setting)	21.0 ma "on" time 0.06 sec
Minimum current output (min. setting)	9.0 ma "on" time 0.025 sec
Maximum current output	25.0 ma "on" time 0.03 sec 25.0 ma "on" time 0.07 sec

the Wisconsin orders. A summary of all the controllers approved in the state up to December 1, 1939, reveals the data shown in Tables 2, 3, and 4**.

The intermittent a-c controllers rather uniformly deliver well up to the maximum allowable current of 25 ma (rms), but most of them are not using anywhere nearly all of the allowable "on" time, the average being 0.054 sec. I believe this is a vital deficiency.

It would seem reasonable to assume that all of the controllers referred to will provide at least some degree of effectiveness. If a battery unit delivering 0.14 ma-sec has any degree of effectiveness, and if the 17 units (35 per cent of the total) averaging 0.737 ma-sec per shock period are in the least effective, then it would seem that a limit of 3 ma-sec is reasonable. The group of battery controllers delivering from 1 to 2 ma-sec includes at least some "weaker" models of most of the important manufacturers.

MISLEADING ADVERTISING

There has been some misleading advertising by certain manufacturers. These manufacturers have two models. One is Wisconsin-approved, the other is not, and probably does not meet Wisconsin specifications. They advertise in such a way as to lead one to believe that all their models are approved and that the units being sold outside of Wisconsin are Wisconsin-approved units. *All units that are approved for sale in Wisconsin must be clearly and permanently marked with the state industrial commission's approval and the date of approval.*

All the codes have as their objective the promotion of safety, and do not insure that a unit is effective or durable, except in so far as safety is affected by the durability of certain parts, such as insulation.

As agricultural engineers, it would seem to be our duty to (1) conduct research aimed to determine minimum current and time limitations that will be effective under varying conditions such as soil type and moisture, varying fence lengths, etc., and (2) develop some plan of bringing before the public a list of controllers that meet these specifications and that also provide reasonable factors of durability and quality, and, in the case of battery-operated units, reasonable battery life. Some of the battery-operated controllers will wear out a dry-cell battery in an extremely short period of time.

There is one other matter of extreme importance. A patent has been granted on the intermittent shock principle as applied to electric fences. Just how broad this may be, I do not know. There are no patents on the continuous type of a-c controller, which can be built much cheaper than the interrupted type. We have had considerable satisfactory experience with the continuous type controller delivering 9 to 10 ma, and it is our belief that an effective controller can be built that will be within the present specifications of the N.E.S.C., which allows 8 ma.

It is probable that this type of controller will not be so satisfactory for great lengths of fence, but we believe that it can be made very satisfactory for a fence of at least a few miles.

There has been much argument relative to lowering the construction standards of battery-operated units. Some even go so far as to say that regulations are not needed for this type. Many have claimed that it would be very difficult, if not impossible, to construct a battery unit that would be dangerous. In reply to this, I wish to say that very simple units constructed of standard equipment have been built for the killing of foxes. Several hundred foxes have been killed with units energized by an ordinary 6-volt dry-cell battery and about 40,000 foxes have been killed with a unit energized by a 6-volt storage battery. Current is applied for about one second, and death is almost instantaneous. The effectiveness is 100 per cent. These units would very likely be equally effective in killing adult humans, if the heart were in the path of the current, as they deliver 250 to 500 ma with an open-circuit voltage of about 300.

Due to the hazards involved, all members of all committees with which I have personally worked are emphatically unanimous in condemning all kinds of homemade controllers. I can show you a simple circuit for a homemade controller energized by a dry-cell battery that will kill adult humans probably 100 per cent of the time. Some of the common types of homemade controllers when energized by 110-volt a-c through a small transformer may be highly dangerous.

CONCLUSIONS

The electric fence is going to be an increasingly important item of farm equipment. If not properly limited in its electrical output, it *is* highly dangerous; if not well constructed, it may *become* dangerous. It is, therefore, important that purchasers be able at least to secure good advice on such purchases, and it would seem preferable in a matter of such grave importance that the purchasers be protected by legislation.

Many of the members of our Society will be consulted for advice regarding purchases of controllers and also pertaining to legislation. It would be highly desirable if we could agree on a uniform program which would permit standardization by manufacturers with resultant lower costs to the farmer. It should be comparatively easy to establish a uniform program at this stage of electric-fence development, when only two or three states have definite regulations.

The formulation of a uniform policy is, I believe, the greatest problem for us in this field today.

**In some cases the same model is sold under several trade names and model numbers. The term "different units" as used in these tables refers to distinctly different models, and eliminates the duplications. One manufacturer makes two models, each of which is sold under eleven different names.

AUTHOR'S NOTE: A very complete bibliography on the subject of electric shock will be found in Electrical Engineering for May 1936 (pp. 514 and 515).

EDITOR'S NOTE: Copies of the Underwriters' bulletins, entitled "Standard for Electric Fence Controllers" and "Electric Shock as It Pertains to the Electric Fence", may be obtained by A.S.A.E. members without charge by writing to Underwriters' Laboratories, Inc., 207 East Ohio Street, Chicago, Illinois.

Problems in Harvesting Malting Barley

By A. J. Schwantes
FELLOW A.S.A.E.

ABOUT a year ago Henry O. Putman, secretary of the Northwest Crop Improvement Association, stated that an unusually large percentage of the barley shipped to Minneapolis in 1938 was so damaged by threshing that it could not be sold for malting purposes. One of the requirements of malting barley is that the skin or coat of the kernel shall not be damaged or broken. The U. S. Official Grain Grade Standard states that not more than 5 per cent of the barley kernels can have mechanical injury to grade "malting". In view of the fact that an increasingly large percentage of the crop was being harvested with combines, the question naturally arose as to whether the combine was in any way responsible for the increase in damaged barley.

As a result, the Northwest Crop Improvement Association supplied a number of manufacturers who sold combines in the malting barley areas with a folder, in which the importance of mechanical damage to barley is emphasized and suggestions were made to remedy the condition. These folders were distributed with new combines sold in the area.

It was felt that it might be desirable to investigate barley harvesting and threshing operations with a view to determining definitely the causes of such damage. Accordingly a uniform survey blank was prepared by representatives of the agricultural engineering departments of North and South Dakota and Minnesota in cooperation with the Northwest Crop Improvement Association, and data were obtained from a number of machines, both combines and stationary threshers, at the time barley was being threshed. A sample of barley was obtained from each thresher or combine.

COMBINE NOT PROVEN CAUSE OF INCREASED DAMAGE

Because of the large number of variables encountered in this type of study and because of the limited number of samples that were obtained, it is impossible on the basis of present available data to arrive at any definite conclusions concerning the causes of barley damage. The data obtained this year indicate certain trends and tendencies and can serve best as a valuable guide in formulating a more comprehensive program of investigations.

In Minnesota a total of twenty-seven machines were tested. Thirteen of these were combines and fourteen were stationary threshers; in South Dakota seventeen combines were observed and nine stationary threshers, and in North Dakota twelve combines. By way of a general comparison between the two types of machines in Minnesota, the average percentage of skinned and broken kernels from the combines was 7.2 and that from the stationary threshers was 4.25, while in South Dakota the average damage from the combines was 6.6 per cent, and although we do not have the data with regard to the average of the stationary threshers, the statement is made in the report that many of them were cracking more than the permissable 5 per cent. The average percentage of damaged kernels from the combines in North Dakota was 4.98.

In Minnesota 86 per cent of the stationary threshers and only 39 per cent of the combines had 5 per cent or less of damage, while in South Dakota the percentage was only 22 per cent for stationary threshers and 41 per cent for combines, and in North Dakota it was 50 per cent for the combines. These data would seem to suggest that damage does not depend as much on the method of harvesting as on other factors. While the immediate cause in many cases appears to be faulty machine adjustment and operation, the real cause in most of these cases at least would seem to be the inexperience and carelessness of the operator. Some of the combines showed damage as low as one per cent.

ADJUSTMENT AND OPERATING FACTORS IN MECHANICAL INJURY

The South Dakota data indicated rather conclusively that the closeness of the concave to the cylinder was an important cause of mechanical injury. High cylinder speed gave slightly more damage than low speed, but it appears that cylinder speed is not the most important cause of damage. It was also found that bent cylinder teeth were responsible for serious damage.

Other factors that were observed included the moisture content of the threshed grain, the length of time the grain had been either in the windrow or in the shock before threshing, the variety of barley, and the yield. From the data at hand it was impossible to arrive at conclusions with regard to the effect of any of these factors on damage. It is felt, however, that some of them, such as moisture content and variety, are probably significant and should be investigated further under controlled conditions.

At the South Dakota experiment station tests were also conducted on the extent to which the blower elevator will damage barley. A series of tests were run operating the blower at various speeds and the per cent of damage was determined. It was found that at speeds ranging from 646 to 1120 rpm the damage was negligible. The recommended speed of the blower used was 800 to 1000 rpm. One run was made at a speed of 1460 rpm which showed 9.67 per cent of damage. This would indicate that damage to grain by a blower elevator is likely to occur when excessive speeds are used. The report of the South Dakota station indicates that it is also desirable not to permit the elevator to run empty occasionally. Within the limit of a low of 11.65 per cent and a high of 15.05 per cent, the moisture content seemed to have little effect on damage by the blower elevator.

Presented before the Power and Machinery Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 5, 1939. The author is associate professor of agricultural engineering, University of Minnesota.

AUTHOR'S NOTE: Data from the South Dakota Agricultural Experiment Station included in this report was furnished by Henry H. DeLong of the agricultural engineering department, and that from North Dakota by Leo E. Holman, extension agricultural engineer.

Transport Wheels for Agricultural Machines

IV. Effect of Outside and Cross-Section Diameters on the Rolling Resistance of Pneumatic Implement Tires

By Eugene G. McKibben and J. Brownlee Davidson
FELLOW A.S.A.E. CHARTER A.S.A.E.

SUMMARY

1 The coefficients of rolling resistance for sixteen pneumatic implement tires (Fig. 1) operated at three loads on five field and road conditions are compared on the bases of their outside and cross-section diameters (Fig. 2).

2 Outside diameter is one of the most important factors affecting the coefficient of rolling resistance, especially on soft loose surfaces.

3 If other factors remain constant, increasing the outside diameter consistently decreases the coefficient of rolling resistance.

4 The relation between the outside diameters of pneumatic implement tires and their coefficients of rolling resistance can be approximated by the equation $C = KD^n$, where C is the coefficient of rolling resistance, D is the outside diameter, and K and n are constants.

5 Varying the cross-section diameter, however, has relatively little effect on the coefficient of rolling resistance, except in the case of very narrow tires operated on soft loose surfaces.

AS AN aid to the study of the effects of outside and cross-section diameters on rolling resistance, the data published in Table 3 of article II of this series were converted to coefficients by dividing each value by its corresponding load[1]. The coefficients of rolling resistance thus obtained for the sixteen tires shown in Fig. 1 are arranged in Table 1 according to increasing outside tire diameter and are shown graphically in Fig. 2.

Outside Diameter. From the data of Table 1 and the graphs of Fig. 2 it appears that outside diameter is one of the important factors affecting the rolling resistance of pneumatic implement tires. This is particularly true on soft, loose surfaces. The effects were consistent, however, for all conditions investigated from a concrete road to deep, loose sand. In each instance increasing the outside diameter decreased the coefficient of rolling resistance for any given cross-section diameter and inflation pressure.

This decreased rolling resistance as the outside diameter of a pneumatic tire is increased is largely explained by the following: (1) Less work is required to flex the tire wall enough to give an equal area of supporting contact; (2) less work is used in the forward movement of soil because of the smaller forward component of the tire's motion at the foremost point of its contact with the soil; and (3) less work is needed to compress the soil because of the narrower track resulting from the narrower soil contact needed to give an equal area of supporting contact.

Exponential Equations. The relationship between the outside diameters of pneumatic implement tires and their rolling resistances for given inflation pressures and field conditions can be approximated by exponential equations of the form $C = KD^n$, where C is the coefficient of rolling resistance, D is the diameter, and K and n are constants.

The equations shown in Fig. 2 were obtained by plotting the data of Table 1 on logarithmic coordinate paper. They are admittedly arbitrary approximations.

The constant K depends, of course, on the unit of measure used, the inflation pressure, and the field conditions, as well as a number of other less important factors.

The constant "n" which is independent of the unit of measure used, appears to be determined largely by the soil conditions. The values shown in Fig. 2 for concrete, bluegrass pasture, and tilled loam are –1.0, –0.3, and –0.8, respectively. The values obtained for rigid wheels with 4-in smooth steel rims, when tested on concrete, timothy-clover meadow, and tilled loam, were –1.0, –0.5, and –0.7, respectively.

Cross-Section Diameter. Study of the data of Table 1 as plotted in Fig. 2 seems to indicate that, where the outside diameter and inflation pressure are held constant, increasing the cross-section diameter has comparatively little effect on the coefficient of rolling resistance, except for extreme conditions. In fact, there is some indication that, on the bluegrass pasture, increasing the cross-section diameter increased the rolling resistance slightly.

On the other hand, the very narrow 4.00-30 and 4.00-36-in tires had comparatively high coefficients of rolling resistance on tilled loam and loose sand. This situation probably results from the failure of these tires to hold a large enough volume of loose soil or sand under compression because of their quite narrow area of supporting contact.

The failure of changes in cross-section diameter to produce consistent effects checks well with similar results

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The authors are, respectively, associate professor of agricultural engineering, and professor and head of the department of agricultural engineering, Iowa State College.

[1]McKibben, E. C. and Davidson, J. B. Transport wheels for agricultural machines: II. Rolling resistance of individual wheels. AGRICULTURAL ENGINEERING 20: 469-473 (December 1939).

FIG. 1 SIXTEEN PNEUMATIC IMPLEMENT TIRES USED TO OBTAIN THE DATA GIVEN IN TABLE 1

TABLE 1. COEFFICIENTS OF ROLLING RESISTANCE[a] AT THREE LOADS ON FIVE ROAD AND FIELD CONDITIONS[b] FOR SIXTEEN PNEUMATIC[c] IMPLEMENT TIRES[d] ARRANGED ACCORDING TO INCREASING OUTSIDE DIAMETER

Outside dia, in	Nominal size,[d] in	Ply[c]	Road and field conditions: A, concrete[b]			B, bluegrass[b]			K, fall seeding[e]			C, tilled loam[b]			D, loose sand[b]		
			Load in pounds														
			500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500
25.0	7.50-10	4	.038	.029[f]	.025[g]	.054	.061[f]	.064[g]	.169	.168		.304	.379[f]	.395[g]	.362	.429[f]	.476[g]
25.5	5.00-16	4	.038	.031[g]		.052	.062[g]	.	.151			.342	.388[g]		.358	.460[g]	
26.5	4.00-18	4	.034[f]	.030[g]		.058[f]	.070[g]		.180[f]			.366[f]			.392[f]		
27.4	9.00-10	4	.034	.031[f]	.029[g]	.056	.060[f]	.065[g]	.154	.167		.278	.331[f]	.319[g]	.308	.388[f]	.431[g]
27.7	6.00-16	4	.034	.027[f]	.021[g]	.056	.060[f]	.060[g]	.147	.159[f]		.300	.319[f]	.355[g]	.286	.338[f]	.417[g]
30.5	7.50-16	4	.022	.025	.025[f]	.050	.054	.055[f]		.142	.140[f]	.268	.268	.280[f]	.272	.293	.322[f]
32.9	9.00-16	6	.034	.038	.042	.056	.061	.054			.150	.270	.269	.249	.250	.281	.272
38.4	4.00-30	4	.024	.018[g]		.050	.057[g]		.128			.286	.322[g]		.278	.319[g]	
42.9	9.00-24	4	.024	.023	.023	.054	.053	.053			.119	.198	.199	.186	.196	.201	.206
43.9	7.50-28	4	.028	.023	.026	.052	.055	.052			.103	.204	.208	.197	.214	.207	.205
44.3	4.00-36	4	.022	.017[g]		.044	.050[g]		.117			.262	.294[g]		.260	.277[g]	
46.6	11.25-24	4	.014[h]	.015[h]	.019[h]	.056[h]	.053[h]	.044[h]			.114	.185[h]	.173[h]	.183[h]	.194[h]	.185[h]	.176[h]
51.5	7.50-36	4	.020	.018	.018	.048	.049	.046				.182	.197	.185	.174	.188	.177
56.3	12.75-32	8	.019[h]	.017[h]	.018[h]	.053[h]	.043[h]	.040[h]				.176[h]	.167[h]	.182[h]	.162[h]	.167[h]	.161[h]
58.6	11.25-36	6	.015[h]	.014[h]	.016[h]	.051[h]	.048[h]	.037[h]				.167[h]	.156[h]	.168[h]	.179[h]	.172[h]	.162[h]
58.9	9.00-40	6	.018[h]	.019[h]	.018[h]	.052[h]	.043[h]	.036[h]				.170[h]	.159[h]	.168[h]	.174[h]	.167[h]	.159[h]

[a]Each value was obtained by dividing the mean of the rolling resistances of three nonconsecutive trials by the load. The pooled standard deviations for the rolling-resistance means for soils A, B, K, C, and D are 2.1, 2.7, 4.0, 5.6, and 10.8 lb, respectively.

[b]Field conditions B, C, and D are described in detail in Tables 1 and 2 and by Figs. 2 to 5 of Part II. Rolling resistance of individual wheels, AGRICULTURAL ENGINEERING 20: 469-473 (December 1939).

[c]Inflation pressure, 16 lb per sq in unless otherwise stated.

[d]See Fig. 1 for tread designs.

[e]Webster loam, fall plowed, disked, spike-tooth harrowed, and seeded to rye. Tests run first week in December when the volume weight and moisture content on an ovendry basis were 69 lb per cu ft and 19 per cent, respectively, and the Iowa penetrometer reading was 4.3 in.

[f]Inflation pressure, 20 lb.

[g]Inflation pressure, greater than 20 lb.

[h]Load 500 lb higher than shown in column heading.

obtained by studies of the influence of rim width on the rolling resistance of rigid wheels[2].

It should be noted, of course, that increasing the cross-section diameter increases the load which can be carried at a given inflation pressure without excessive flexing of the tire walls.

Inflation Pressure. The importance of inflation pressure is also emphasized by Fig. 2. For the tests on loose sand and tilled loam the coefficients of rolling resistance are noticeably larger with higher inflation pressures, while for the tests on concrete the coefficients are consistently smaller with higher pressures. On the intermediate surfaces, bluegrass pasture and fall seeding, however, the effects of inflation pressure appear to be relatively unimportant. These observations are entirely consistent with the results outlined in the preceding article[3].

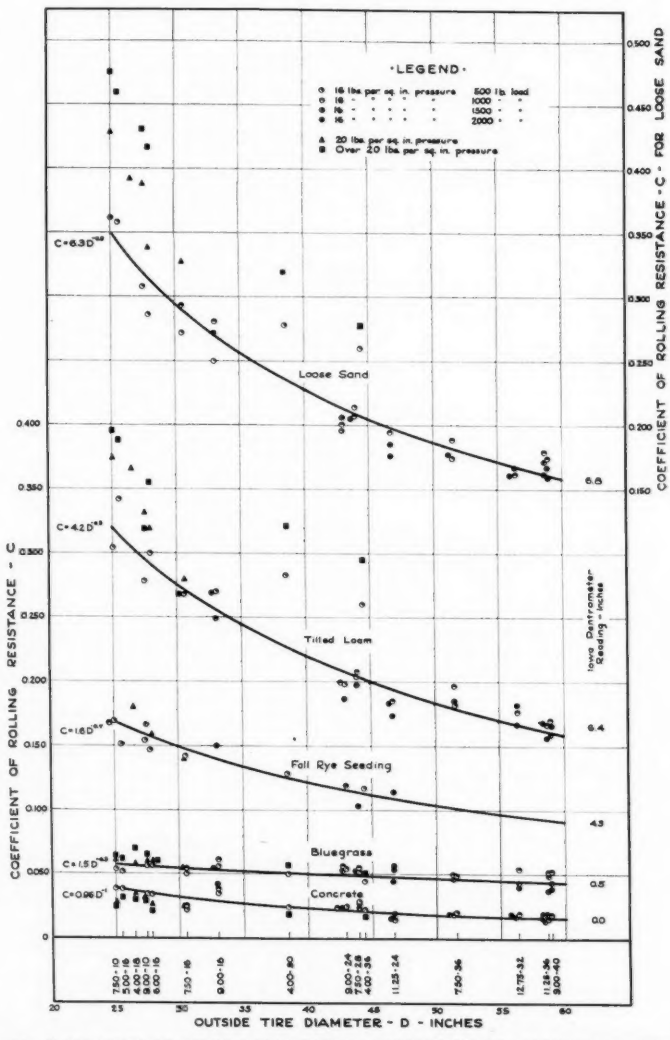


FIG. 2 RELATION OF OUTSIDE DIAMETER TO COEFFICIENT OF ROLLING RESISTANCE FOR THE SIXTEEN TIRES SHOWN IN FIG. 1 ON FIVE ROAD AND FIELD CONDITIONS, PLOTTED FROM DATA GIVEN IN TABLE 1

[2]Research Bulletin No. 231, Iowa Agricultural Experiment Station, 1938.

[3]McKibben, E. G. and Davidson, J. B. Transport wheels for agricultural machines, III. Effect of inflation pressure on the rolling resistance of pneumatic implement tires. AGRICULTURAL ENGINEERING 21: 25-26 (January 1940).

Degree and Length of Land Slope as It Affects Soil Loss in Runoff

By Austin W. Zingg

THIS study was initiated to better evaluate the effects of degree and length of land slope upon soil loss, and to serve as a guide for subsequent experimentation which should ultimately lead to precise determination of these effects. The results of research work by various individuals and organizations are grouped and analyzed as a whole to develop a rational equation for soil loss with respect to degree and horizontal length of slope. Results of an original experiment involving several plots with variations of slope and horizontal length are given. It is not assumed that the equation obtained represents absolute values for any specific soil or condition but is merely an average of available data on the subject.

DEGREE OF SLOPE

Few experiments have been conducted which cover sufficient ranges of degree of land slope to permit evaluation of this factor as it is related to soil loss. Most plots studied under field conditions are widely separated in location, or the surface soil has been manipulated to produce varying degrees of slope. Under such conditions the infiltration rates and physical properties of soils in the same experiment can be greatly different, and give results which do not necessarily represent the effect of slope alone.

Research conducted at the Kansas agricultural experiment station[1]* and the agricultural experiment station of the Alabama Polytechnic Institute[2] seem to best approach the requirements necessary for a study which will properly evaluate slope with a degree of freedom from the influences of other variables.

The results of six tests are graphically recorded in Fig. 1. Two are from the data secured by F. L. Duley and O. E. Hays on a Kansas silty clay loam and on Kansas sandy loam soils. The tests on the silty clay loam were conducted in a laboratory upon prepared plots 24 in wide, 28 in deep, and 10 ft long. Plot slope differences were obtained by use of a differential hoist, and water application was by means of the sprinkling can method. The rate of water application was one inch per hour. The studies on Kansas sandy loam were carried out upon field plots 38.85 in wide and 25 ft long. Water application was by means of sprinkling cans at the rate of 2 in in 30 min. The surface soil, which was in a fallow condition, was saturated prior to both series of tests.

The four tests by E. G. Diseker and R. E. Yoder were made on a Cecil clay soil. The plots used were 15 ft wide and 50 ft long. The plots having different slopes were located in adjacent order and separated by concrete walls. Soil was carefully filled in to secure the various degrees of slope. The materials were tamped to their normal volume weight and a surface soil added. Mechanical analysis of the soils showed their texture to be uniform from plot to plot. Water was applied by use of a Skinner type irrigation system and distributed with "catfish" nozzles. Tests on smooth fallow ground and on freshly plowed ground were made upon a saturated soil with 1.25 in of water applied in 11 min. The results listed in Fig. 1 for a freshly cultivated, and for a compact and crusted surface soil condition, were made on plots planted to cotton in 3-ft contour rows, with a field moisture condition preceding a rate of water application of 2 in in 18 min. While the results obtained from these four runs on different soil conditions are rather erratic, the four of them combined represent soil conditions which occur throughout different periods of the year. Their average is similar to the trends obtained by Duley and Hays.

It is noted that several soils and various sizes of plots have been used and different rainfall intensities and amounts have been applied to them. The soil losses are consequently greatly different in quantity for the various groups of data, and direct comparisons are not possible. The published absolute values of total soil loss have therefore been adjusted by a system of coding for the purpose of comparison.

In Fig. 1 a curve is drawn through the average of the coded total soil loss. Logarithmic plotting of this average of the data shows the coded total soil loss to be proportional to the 1.49 power of slope, or

$$X_c = 0.065\, S^{1.49},$$

in which X_c = coded total soil loss, and S = land slope in per cent.

A rational equation representing total soil loss for a general condition could therefore be

$$X = CS^m,$$

in which X = total soil loss in weight units, C = a constant of variation, S = land slope in per cent, and superscript "m" = exponent of land slope.

The question arises as to whether results from experiments of the foregoing type are applicable to field conditions, since they do not fully cover the range of intensities and infiltration rates common to field areas throughout the year. All data listed have been obtained from a saturated soil condition where the infiltration rate has been low, or with high rates of water application which have minimized the effect of infiltration. Under field conditions, where a rain is of relatively short duration and has a rate slightly in excess of the infiltration rate, soil loss may be obtained from a steep slope, whereas a relatively moderate slope would give no runoff or soil loss because of greater depression storage. However, since the major part of soil loss over a year's time appears to occur from a relatively few rains of high intensity, and from rainfall on soil having a relatively low infiltration rate, the exponent of slope obtained from the several experiments may be very close to that which may be obtained from field conditions. Unpublished data obtained from degree of slope in continuous corn at the University of Missouri show an exponent for slope only slightly less than the average for the data presented in Fig. 1. These plots have been under observation for a 10-yr period under natural rainfall conditions.

HORIZONTAL LENGTH OF LAND SLOPE

Available data from several midwestern experiment stations of the U. S. Soil Conservation Service have been

The author is assistant agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture, stationed at Bethany (Mo.) soil conservation experiment station.

*Superscript figures refer to literature cited at the end of Mr. Zingg's paper.

grouped for the study. Those grouped are from Tyler, Texas[3], Guthrie, Okla.[4], Clarinda, Iowa[5], Bethany, Mo.[6], and LaCrosse, Wis.[7] The horizontal lengths of plots at the stations are 36.3, 72.6, and 145.2 ft, and all are in continuous intertilled crops of corn or cotton.

The total soil losses in runoff, (tons per plot per year) for each station have been adjusted by a system of coding for purposes of comparison. These coded total yearly soil losses are plotted against horizontal length in Fig. 2. A curve is drawn through the average of the coded soil losses. Logarithmic plotting of this average of the data shows the coded total soil loss to be proportional to the 1.53 power of the horizontal length of slope, or

$$X_c = 0.0025\, L^{1.53},$$

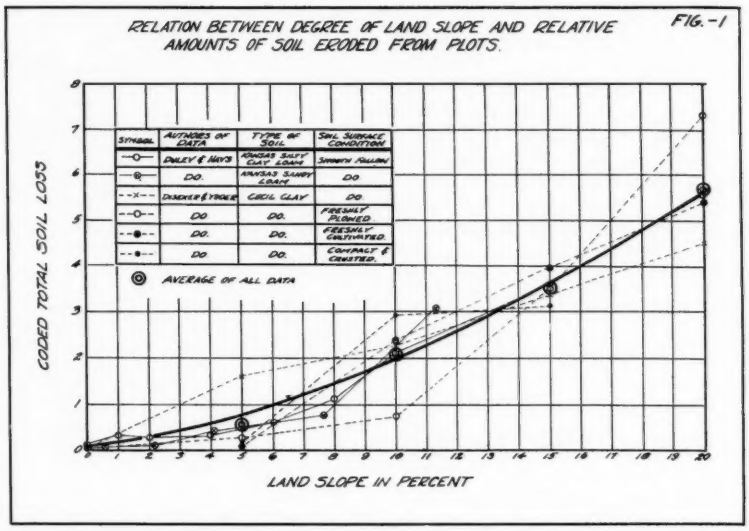
in which X_c = coded total soil loss, and L = horizontal length of land slope in feet.

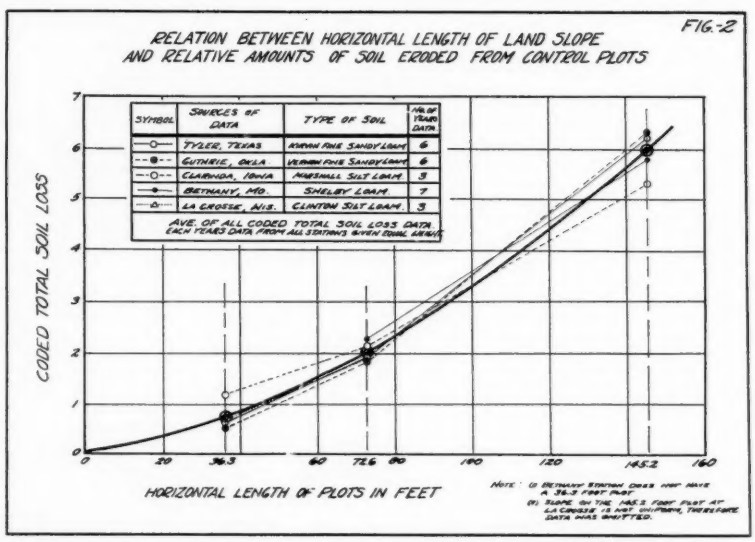
It is apparent that there is only a small divergence in the exponential value of the horizontal length of slope for the various stations. When it is considered that the soils are different in formation, the infiltration rates have a large range of values, and the areas receive different quantities and intensities of precipitation, the fact that all data deviate so little from the average is worthy of note.

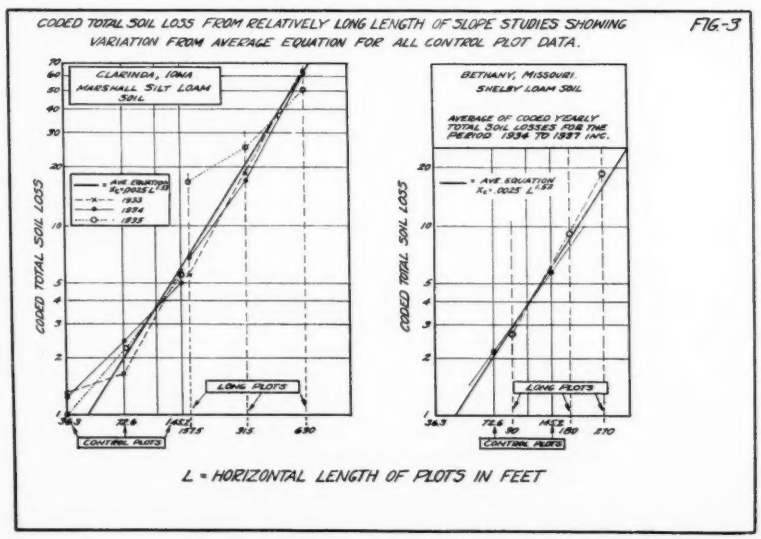
After averaging the coded data from the relatively short lengths of the control plots, data from other experiments of greater plot length were compared with this average to ascertain whether the same trend of soil loss is operative.

Fig. 3 shows the variation in data from all length of slope studies at the Clarinda, Iowa, and Bethany, Mo., stations. Both stations have plots of greater length than the control plots. Their respective lengths are shown on the abscissa of the graphs.

The Clarinda plots are located on a Marshall silt loam which has an exceedingly high infiltration rate. The data obtained at the Clarinda station during 1934 and 1935 show lesser increases of total soil loss from increased length of plots than the curve representing the general average for all data studied. Soil loss during this time was exceptionally low due to severe drought and high temperatures. An exceptionally high infiltration rate undoubtedly prevailed with these conditions. In 1933, which was the year preceding the drought condition, there was a greater increase in total soil loss for increased length of plots than the average for all stations in three out of


RELATION BETWEEN DEGREE OF LAND SLOPE AND RELATIVE AMOUNTS OF SOIL ERODED FROM PLOTS.
FIG.-1
CODED TOTAL SOIL LOSS
LAND SLOPE IN PERCENT
AVERAGE OF ALL DATA


RELATION BETWEEN HORIZONTAL LENGTH OF LAND SLOPE AND RELATIVE AMOUNTS OF SOIL ERODED FROM CONTROL PLOTS
FIG.-2
CODED TOTAL SOIL LOSS
HORIZONTAL LENGTH OF PLOTS IN FEET
AVE. OF ALL CODED TOTAL SOIL LOSS DATA, EACH YEARS DATA FROM ALL STATIONS GIVEN EQUAL WEIGHT


CODED TOTAL SOIL LOSS FROM RELATIVELY LONG LENGTH OF SLOPE STUDIES SHOWING VARIATION FROM AVERAGE EQUATION FOR ALL CONTROL PLOT DATA.
FIG.-3
CLARINDA, IOWA MARSHALL SILT LOAM SOIL
BETHANY, MISSOURI. SHELBY LOAM SOIL
AVERAGE OF CODED YEARLY TOTAL SOIL LOSSES FOR THE PERIOD 1934 TO 1937 INC.
CODED TOTAL SOIL LOSS
LONG PLOTS
CONTROL PLOTS
L = HORIZONTAL LENGTH OF PLOTS IN FEET

four comparisons. Musgrave[5] points out the fact that decreased runoff may occur with increased length of slope and expresses the belief that relation of rainfall intensity to infiltration rate is a determining factor. Data reported by Lowdermilk and by Hendrickson show that pore space in the immediate surface soil becomes clogged by small particles from turbid water during periods of intense rainfall. Neal[8], applying artificial rainfall to plots on Putman silt loam, has shown that the open structure of the top layer of soil is destroyed by intense applications of water. With a return to more normal climatic conditions, it is possible that total soil loss may be represented by a greater exponential value for length than occurred in 1934 and 1935. It is to be noted that the coded total soil loss from the group of longer plots follows a similar relationship to the average of coded total soil loss from the control plots.

The graph (Fig. 3) for data from the Bethany station on a Shelby loam soil presents a comparison of coded total soil loss from the control plots and a series of relatively long plots with respect to the average of all data in Fig. 2. The two lengths of slope under study in the control plots (72.6 and 145.2-ft plots) show less increase in relative total soil loss for increased length than the other group (90, 180, and 270-ft plots). The data from the control plots may follow a relatively low exponential value for horizontal length due to the manner in which the plots were prepared. The 145.2-ft plot was filled in with additional surface soil on the upper end to obtain a uniform slope at the beginning of the experiment, thus changing the original surface profile from a convex shape to a uniform slope. The additional depth of topsoil undoubtedly gives the upper portion of the plot a higher infiltration rate than the 72.6-ft plot. As erosion has progressed on the 145.2-ft plot for a period of years, the surface has assumed a concave profile. The concrete wall at the lower end of the plot prevents lowering of the soil surface level at this point. At the present time there are several inches of topsoil adjacent to the concrete wall on the lower end of the plot; on the middle portion of the plot the surface soil is entirely gone and a glacial till is exposed; and the upper portion of the plot, which was originally built up with additional surface soil, has about one foot of surface soil remaining on it. The plots of the longer slope group (90, 180, and 270-ft plots) were located on a virgin soil in 1934. The longer plots have colluvial soil on their lower portion, and it is possible the coded total soil loss for increased length is represented by a greater exponent for length due to the more erosible nature of the colluvial materials. It is also possible that total soil loss is proportional to the horizontal length of the plot to a power which will increase with the horizontal length of slope. This comparison of the two groups of plots is given to show some of the uncontrolled variables which occur in studies of this type and to bring out the fact that the differences obtained on parallel experiments on one soil type are nearly as great as the deviations between all stations. It would also indicate that present information on the subject is too meager to permit more than broad generalizations to be made at the present time.

From the study of the data it is believed a rational equation representing total soil loss for a general condition can be expressed as

$$X = CL^n$$

in which X = total soil loss in weight units, C = a constant of variation, L = horizontal length of land slope in feet, and superscript "n" = exponent of horizontal length of land slope.

In Table 1 all published annual total soil loss data from the experiment stations are tabulated. In this instance the data are presented as ratios produced by doubling the horizontal length of slope. The several length comparisons are specified. The same data are presented in the form of a frequency distribution curve in Fig. 4. The value of the median, or the value selected so that twenty-five, or half the cases, have lesser ratios and an equal number have greater ratios than this value, is 2.84. If this median value is used as the effect of doubling horizontal slope length, the value of (n), the exponent of length, is (1.5). If the value of the arithmetic mean (3.03) is used, the value of (n) will be (1.6).

TABLE 1. SOIL LOSS RATIOS PRODUCED BY DOUBLING LENGTH OF PLOTS

Experiment station	Year	Length of plots compared, feet	Yearly soil loss ratio, long plot/short plot
BETHANY, MO.	1931	145.2 – 72.6	2.50
	1932	" "	2.15
	1933	" "	2.52
Soil type,	1934	" "	2.28
Shelby loam	1935	" "	2.84
	1936	" "	2.25
	1937	" "	3.80
	1934	180.0 – 90.0	3.33
	1935	" "	4.87
	1936	" "	3.22
	1937	" "	4.16
		Average,	3.08
CLARINDA, IOWA	1933	72.6 – 36.3	1.24
	1934	" "	1.91
	1935	" "	2.20
Soil type,	1933	145.2 – 72.6	3.55
Marshall silt loam	1934	" "	2.02
	1935	" "	2.44
	1933	315.0 – 157.5	3.39
	1934	" "	2.46
	1935	" "	2.39
	1933	630.0 – 315.0	3.45
	1934	" "	3.65
	1935	" "	2.01
		Average,	2.56
LA CROSSE, WIS.	1933	72.6 – 36.3	3.90
Soil type,	1934	" "	2.62
Clinton silt loam	1935	" "	2.60
		Average,	3.04
GUTHRIE, OKLA.	1931	72.6 – 36.3	1.72
	1932	" "	2.92
Soil type,	1933	" "	3.34
Vernon fine	1934	" "	2.23
sandy loam	1935	" "	1.95
	1936	" "	4.20
	1931	145.2 – 72.6	1.65
	1932	" "	4.21
	1933	" "	2.60
	1934	" "	4.62
	1935	" "	4.80
	1936	" "	5.05
		Average,	3.27
TYLER, TEXAS	1931	72.6 – 36.3	3.49
	1932	" "	2.84
Soil type,	1933	" "	2.67
Kirvin fine	1934	" "	2.98
sandy loam	1935	" "	2.84
	1936	" "	3.29
	1931	145.2 – 72.6	2.53
	1932	" "	5.02
	1933	" "	3.66
	1934	" "	3.86
	1935	" "	3.16
	1936	" "	2.21
		Average,	3.21

Average for all ratios, 3.03
Median value of all ratios, 2.84

COMBINED EFFECT OF DEGREE AND LENGTH OF LAND SLOPE

The following symbols will be used in this discussion:

S= degree of land slope

L= horizontal length of land slope

X= total soil loss from a land slope of unit width

C= a constant of variation

m= exponent of degree of land slope

n= exponent of horizontal length of land slope

A= average soil loss per unit area from a land slope of unit width.

From the development of material under the sections on degree of slope and horizontal length of slope, and with the above symbols in mind, it was determined that $X=CS^m$ and $X=CL^n$. It was found, in several experiments where degree of slope was a variable, that the value of (m) appeared to be independent of the lengths of plots used in conducting the experiments; conversely, the length of slope experiments at the several stations were conducted on slopes of various degree, and the values of (n) are not greatly different. It is believed that both degree of slope and horizontal length of slope may, for practical purposes, be considered independent variables in their relation to soil loss. Their effect would thus be expressed as

$$X = CS^mL^n$$

$$A = CS^mL^{n-1}$$

EXPERIMENT IN WHICH THE EFFECT OF DEGREE AND LENGTH OF LAND SLOPE ARE SIMULTANEOUSLY EVALUATED

Procedure. A group of eight plots in which three degrees of slope, 4, 8, and 12 per cent, and two horizontal lengths, 8 and 16 ft, are represented, were prepared for the study. All plots were 4½ in wide. The 4, 8, and 12 per cent slope plots were 8 ft in horizontal length. Each slope and length was duplicated at random location to give a record of the variability and to serve as a check on values attained.

The plots were located on an original 8 per cent Shelby loam slope. The original surface soil was entirely removed, the desired plot grades were established on the subsoil, and steel plot divides were placed to serve as plot boundaries. An 8-in depth of surface soil, which had been mixed and sifted through a one-inch mesh screen to produce uniformity, was then added to the plots. Concentrating

FIG-4

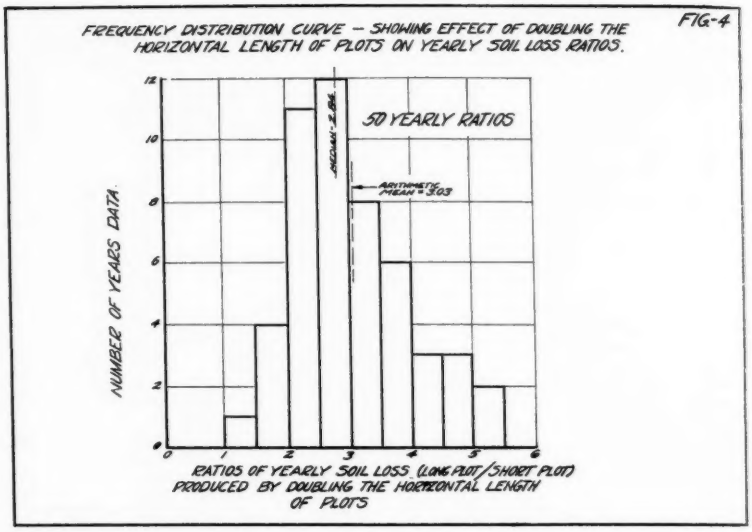

FREQUENCY DISTRIBUTION CURVE — SHOWING EFFECT OF DOUBLING THE HORIZONTAL LENGTH OF PLOTS ON YEARLY SOIL LOSS RATIOS.
50 YEARLY RATIOS
MEDIAN = 2.86
ARITHMETIC MEAN = 3.03
NUMBER OF YEARS DATA
RATIOS OF YEARLY SOIL LOSS (LONG PLOT/SHORT PLOT) PRODUCED BY DOUBLING THE HORIZONTAL LENGTH OF PLOTS

FIG-5

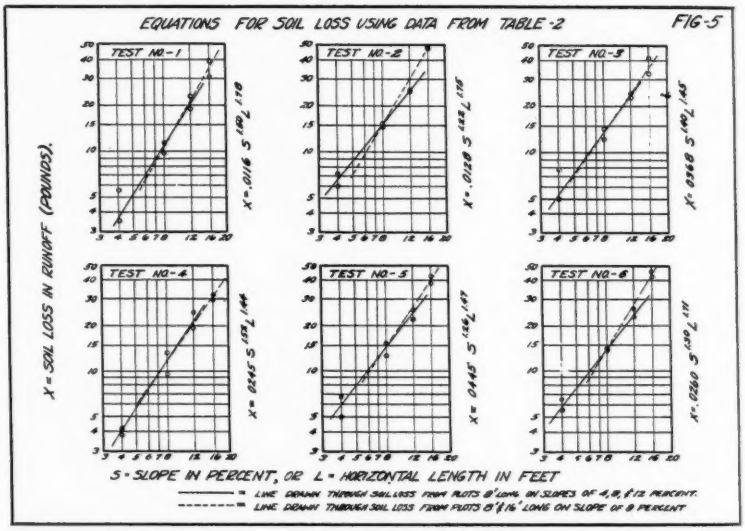

EQUATIONS FOR SOIL LOSS USING DATA FROM TABLE-2
TEST NO-1
TEST NO-2
TEST NO-3
TEST NO-4
TEST NO-5
TEST NO-6
X = SOIL LOSS IN RUNOFF (POUNDS).
S = SLOPE IN PERCENT, OR L = HORIZONTAL LENGTH IN FEET
LINE DRAWN THROUGH SOIL LOSS FROM PLOTS 8' LONG ON SLOPES OF 4, 8, & 12 PERCENT.
LINE DRAWN THROUGH SOIL LOSS FROM PLOTS 8' & 16' LONG ON SLOPE OF 8 PERCENT

FIG-6

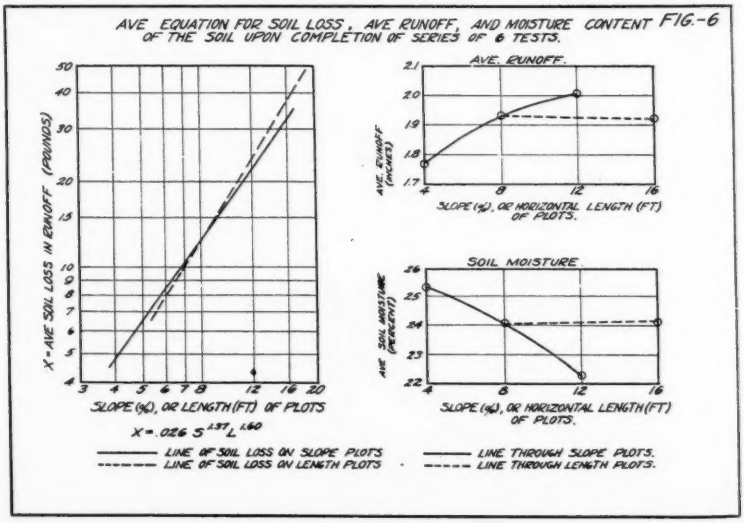

AVE EQUATION FOR SOIL LOSS, AVE RUNOFF, AND MOISTURE CONTENT OF THE SOIL UPON COMPLETION OF SERIES OF 6 TESTS.
X = AVE SOIL LOSS IN RUNOFF (POUNDS)
SLOPE (%), OR LENGTH (FT) OF PLOTS
X = .026 S^1.37 L^.60
AVE. RUNOFF.
AVE. RUNOFF (INCHES)
SLOPE (%), OR HORIZONTAL LENGTH (FT) OF PLOTS.
SOIL MOISTURE.
AVE. SOIL MOISTURE (PERCENT)
SLOPE (%), OR HORIZONTAL LENGTH (FT) OF PLOTS.
LINE OF SOIL LOSS ON SLOPE PLOTS
LINE OF SOIL LOSS ON LENGTH PLOTS
LINE THROUGH SLOPE PLOTS.
LINE THROUGH LENGTH PLOTS.

TABLE 2. RESULTS SECURED FROM TESTS

Symbol No.	Plot Length, ft	Slope, per cent	Test number 1	2	3	4	5	6	Averages 1-6	
			Pounds of soil loss in runoff							
1-A	8	4	3.53	7.14	7.74	4.20	6.74	5.63	5.83	Soil
1-B	8	4	5.68	5.93	5.05	3.77	5.05	6.44	5.32	moisture
2-A	8	8	11.36	15.55	12.20	9.40	12.75	13.71	12.50	content
2-B	8	8	9.68	14.76	14.57	13.44	15.40	13.85	13.12	in 12-in
3-A	8	12	23.19	25.94	24.30	24.41	26.51	26.42	25.13	depth upon
3-B	8	12	18.91	24.55	23.20	18.77	21.67	23.28	21.73	completion of
4-A	16	8	39.60	48.23	41.57	32.09	43.47	43.15	41.35	six tests,
4-B	16	8	30.65	46.90	33.56	29.72	37.06	46.72	37.44	per cent
			Inches of water loss							
1-A	8	4	1.41	1.82	1.75	1.54	1.87	1.87	1.71	24.9
1-B	8	4	1.75	1.86	1.85	1.78	1.86	1.89	1.83	25.7
2-A	8	8	1.74	1.91	1.91	1.88	1.86	1.89	1.87	24.4
2-B	8	8	1.95	2.05	2.10	1.90	2.00	1.93	1.99	23.5
3-A	8	12	1.92	2.06	2.15	2.13	2.08	2.10	2.07	22.3
3-B	8	12	1.84	2.12	2.06	1.99	2.03	1.94	2.00	23.0
4-A	16	8	1.96	1.99	1.89	1.95	1.95	1.91	1.94	24.7
4-B	16	8	1.85	1.94	1.83	1.82	1.92	2.04	1.90	23.5
Water applied	Amount	In	2.34	2.37	2.37	2.35	2.32	2.36	2.35	
	Rate	In/hr	3.12	3.16	3.16	3.13	3.09	3.15	3.13	

troughs were placed at the lower edge of the plots and downspouting was used to conduct runoff to barrels sunk in the ground.

The rain simulator developed at the Bethany station and described in detail in a preliminary draft of a manuscript by C. M. Woodruff, D. D. Smith, and Darnell M. Whitt[9] was used to apply water to the plots. A rainfall rate of 3.15 in per hour was applied for a 45-min period for all tests made. The one intensity was used due to the fact that drop size will vary with changes in pressure head, for the type of rain simulator used, introducing a variable in addition to variation of the intensity of rainfall. The rate and amount of water applied has a frequency of occurrence of once in 20 yr, based on data by Yarnell[10].

The surface of the plots was cultivated with a rake to a depth of 3 in, preceding each of six tests. The condition of the soil for each run would represent a freshly prepared seedbed, with the surface soil in a moist, loose, granular condition and the subsoil wet. The choice of applying simulated rainfall to this soil condition, in preference to any other, was made because it is representative of one from which a large percentage of soil loss appears to occur in the field. It closely resembles ground in cultivated corn or cotton; and small grain, soybean, or alfalfa seedbed preparation.

The six tests were made on successive days in an attempt to have the plots as near to the same moisture content for each run as possible.

Results. All data collected are listed in tabular form in Table 2. The soil loss in runoff for each of the six tests is plotted on logarithmic scales in Fig. 5. The lines which best fit the data for each are drawn and the equation being followed is given. The equation given is based on the assumption that like values of (m), the exponent of slope in per cent, and (n), the exponent of horizontal length in feet, would be obtained had the experiment been conducted on plots with lengths greater or less than those used. This is not necessarily the case, as will be seen under the heading *"Discussion"* following.

In Fig. 6 all equations shown in Fig. 5 have been averaged and a graph of the average total soil loss ($X=0.026\ S^{1.37}L^{1.60}$) is shown. Values of S (slope in per cent), and L (horizontal length in feet) may be substituted directly in the equation to obtain pounds of soil loss in runoff. Using the average values of (m) and (n) (the exponents of slope and length, respectively), doubling the degree of slope increased the soil loss 2.61 times, and doubling the horizontal length of slope increased the total soil loss 3.03 times.

Graphs for the total average runoff in surface inches and the per cent soil moisture content for each slope and length studied are illustrated in Fig. 6. Runoff increased appreciably with increases of slope and decreased a very small amount with additional length of slope for the rainfall intensity applied. The soil moisture content of the plots shows an inverse relationship to runoff.

Discussion. Since unequal rates of infiltration have occurred on the different slopes and horizontal lengths of slope studied, it is apparent that any factor which changes this relationship will be reflected in the values of the exponents (m) and (n). A relatively low value of (n) was secured by Neal*. It is therefore probable that an equation for soil loss in relation to both degree and horizontal length of land slope could be expressed as follows:

$$X = [C = f(K)]\ S^{m=f(K,L)}\ L^{n=f(K,S)}$$

in which K represents infiltration rate, physical properties of the soil, intensity and duration of the rain, and other factors.

The purpose of the experiment was to obtain relationships for conditions approximating those from which a large portion of soil loss occurs in the field. For practical purposes the relationship $X = CS^mL^n$, will be of value as a rational equation until more exacting relationships are attained.

It is interesting to note that the relative value of total soil loss, 2.61 (the equivalent of doubling the degree of slope when $m = 1.37$), is somewhat less than the average of 2.80 (where $m = 1.49$) obtained by averaging the coded total soil loss from several experiments under the section on degree of slope. The value 3.03 (effect of doubling the horizontal length of slope on soil loss) is equal to the arithmetic mean of the fifty yearly ratios of soil loss listed in Table 1 of the section on length of land slope. Since the effect upon total soil loss by increasing the horizontal length of slope has been found to be the same by the two methods of approach, it follows that the value of ($m = 1.37$) is probably close to a contemporaneous

*Neal[8], evaluating the effect of degree of slope on a Putman soil in a laboratory plot having a constant length of slope, found the soil loss varied as the 0.7 power of the slope. The amounts of soil loss were obtained after water had been applied for periods of time greater than one hour. The Putman soil has a low minimum infiltration rate, and the runoff from all slopes approached equality.

value for the degree of slope which would be attained as an average of field conditions.

Subsequent use will be made of the rational equation $X = CS^{1.4}L^{1.6}$.

SUMMARY

Available data on soil loss in runoff from degree and horizontal length of land slope experiments were studied by a system of coding. From an average of these coded data it was found that (1) doubling the degree of slope increased the total soil loss 2.80 times, and (2) doubling the horizontal length of slope increased the total soil loss 3.03 times.

An experiment, in which a simulated 20-year frequency rainfall was simultaneously applied to various degrees of slope and horizontal lengths of land slope, was conducted on small plots. For an average of the tests conducted on these plots, the following occurred:

1 Doubling the degree of slope increased the total soil loss in runoff 2.61 times.

2 Doubling the horizontal length of slope increased the total soil loss in runoff 3.03 times.

3 Increasing the degree of slope increased the total runoff.

4 Increasing the length of slope decreased the total runoff.

5 The moisture content of the soil at the completion of the tests showed an inverse relationship to total runoff.

For practical purposes, the rational equation $X=CS^{1.4}L^{1.6}$ will give a relation between total soil loss, degree of slope, and horizontal length of slope which, as a generalization, will be applicable to field conditions. The equation is based upon a limited amount of data which was not developed for the purpose of this study, and when more satisfactory data are available, refinements will undoubtedly be possible.

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[10]Yarnell, D. L. Rainfall intensity-frequency data. U. S. Dept. Agr. Misc. Pub. 204. 1935.

AUTHOR'S NOTE: The author acknowledges the assistance of Dwight D. Smith and Darnell M. Whitt in the collection and interpretation of the data presented.

EDITOR'S NOTE: The study on which the foregoing paper was based, is believed to be the first of its kind, at least of such comprehensive scope. The results yielded are of value, and form the background for a paper, entitled "An Analysis of Degree and Length of Slope Data as Applied to Terracing," which was presented by the author before the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 8, 1939, and which will be published in AGRICULTURAL ENGINEERING for March. The author believes that most of the questions raised at the time the latter paper was presented will be cleared up in the foregoing paper.

Soil Conservation Engineering

THE physical land-use adjustment programs—erosion control, irrigation and drainage, the farm phase of flood control, the water-facilities program, submarginal-land purchase and development, and farm forestry—are now a function of the Soil Conservation Service. The amalgamation of these varied activities has resulted in an enlargement or broadening of policies, and their administration has necessitated adjustments in the original Soil Conservation Service organization. Although divisions of the Service have felt the effect in one way or another, the engineering work probably has increased more in variety and magnitude than any other branch.

The nature of the various programs now administered by the Service diverts automatically a large share of the field responsibilities to the engineers of the Service. The development of purchased submarginal lands involves a variety of engineering activities. Areas designated for grazing require fencing and livestock watering developments. Roads, impounding dams, numerous types of buildings, as well as other structural improvements, are required on areas to be used for recreational and wildlife purposes. The transfer of the departmental drainage and irrigation activities, two well-established fields of engineering work, places additional responsibilities on the Service. The productivity of large agricultural areas is dependent upon proper design, installation, and maintenance of suitable drainage and irrigation systems.

As in all new engineering fields, there is a woeful lack of experience, precedent, and fundamental research information. Upon analysis, most problems require scientific data and tested practice for their solution. The same fundamentals of hydraulics, mathematics, physics, mechanics, etc., that are used in established engineering fields are necessary, but they require new applications. Agricultural engineers soon discovered that the prevention of erosion, the drainage of flat lands, or the irrigation of arid farms was not simply a matter of building structures or designing hydraulic channels. Of greater importance is the drafting of a comprehensive procedure to harmonize with proper land use, cropping requirements, variation in soil types, and farming practices or organization. Due to their training or natural inclinations, many engineers tend to limit their vision of specific problems to the immediate details of a ponderable mass of hydraulic or mathematical formulations and to overlook the ultimate objective or proper application of engineering in agriculture. The adoption of a comprehensive view, without sacrificing necessary fundamentals, is essential for success.—*From an article of the same title by T. B. Chambers, in "Soil Conservation" for January 1940.*

A Small Low Cost Concrete Grain Bin

By G. B. Hanson
MEMBER A.S.A.E.

ALTHOUGH concrete has long been the dominant material in construction of large grain bins and grain elevators, it has been a much less important material in construction of small farm grain storages. Giving some thought to this situation, and stimulated by the greatly increased demand for farm bins of 1000 to 2000-bu capacity during the past two years, it was decided to build a 1000-bu experimental concrete bin. Design features not commonly employed were incorporated in the experimental bin with the object of lowering costs and simplifying construction work.

The problem encountered in developing the new bin was threefold:

1 The bin must be low in cost to meet substantial acceptance, since farmers are today generally paying in the range of 13 to 20 cents per bushel for bins of average quality with capacities of 1000 to 2000 bu.

2 The design must provide for a bin of fairly permanent construction so that the cost per year of service may be low, with little upkeep required. Steps in building the bin must be simple enough that average rural builders using some inexperienced help can perform a satisfactory job.

3 Construction developed must provide adequate storage for the grain.

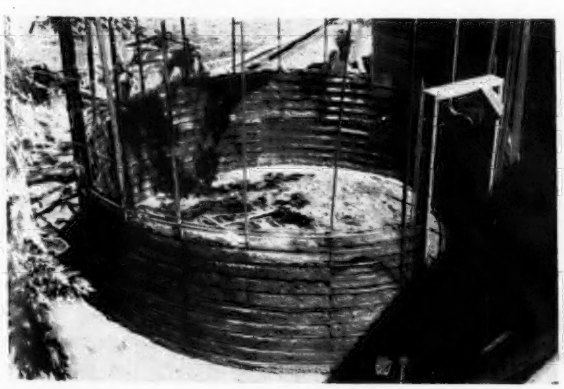
In view of the above requirements it was decided that a circular bin of reinforced concrete which could be built entirely without forms would perhaps best meet our needs. Design details of this bin are shown in the attached drawings. It will be observed that the foundation is placed without forms in an 8-in trench dug with a tiling spade. Wall reinforcement consists of two rows of $\frac{3}{8}$-in ribbed, expanded metal lath having a weight of 4 lb per sq yd. The two rows of metal lath are separated by and fastened to 3-in hollow metal partition studs spaced 2 ft on centers. The ribbed metal lath was supplied in 24-in widths and lengths of 10 and 12 ft formed to the proper curve by the manufacturer.

Presented before the Farm Structures Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 5, 1939. The author is agricultural engineer, Portland Cement Association.

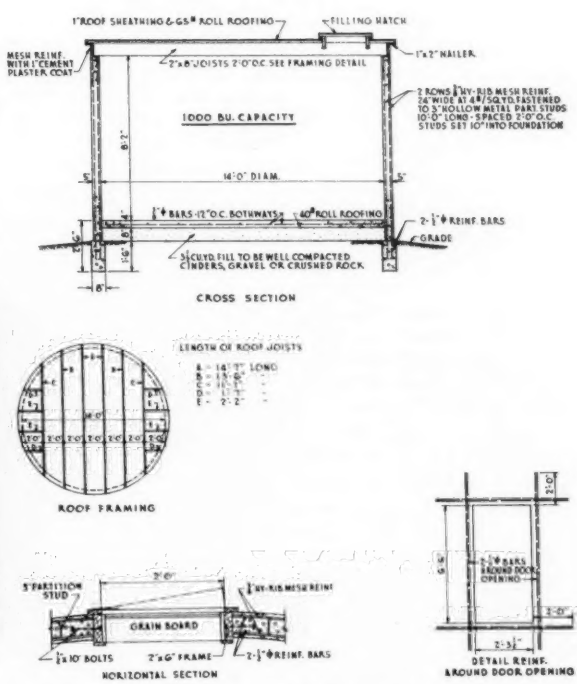
In the case of the 2000-bu bin it is necessary to add three $\frac{1}{4}$-in round bars in the lower part of the wall to supplement the mesh reinforcement.

The reinforced concrete floor is placed well above grade to promote dryness, and as an extra precaution, 40-lb roll roofing with the joints well lapped and cemented is placed on a well-compacted fill, the top of which has been hardened, sealed, and made smooth with a thin slush coat of cement grout. Then a 4-in reinforced concrete floor is placed, reinforcement consisting of $\frac{3}{8}$-in round bars 12 in on centers both ways. Experience shows that this type of floor is dry, permanent, and convenient to work on. As shown in the drawings, a flat roof of wood joists spaced 2 ft on centers, with tight sheathing and best quality roll roofing, was designed. A simple flat top filling hatch is also shown, and if required a central flue ventilator may readily be incorporated in the plan. Additional reinforcement consisting of $\frac{1}{2}$-in round bars was required to take stress around the door opening in the bin.

The bin actually built on an Iowa farm was the 1000-bu capacity bin shown in the drawings. The foundation trench was excavated to the required depth and diameter, then filled with concrete up to a level equal to the approximate grade. As shown in the plans, two $\frac{1}{2}$-in round reinforcing bars were placed near the top of the foundation. Then sections of wall reinforcement were set in place before the concrete foundation hardened, anchoring the studs into the foundation to a depth of about 10 in. It was found most convenient to fasten the *(Continued on page 68)*



EXPERIMENTAL 2000-BU GRAIN BIN UNDER CONSTRUCTION, SHOWING HOLLOW METAL PARTITION STUDS, TWO ROWS OF METAL LATH, CONCRETE FILLING, AND WOOD DOOR FRAME



CONSTRUCTION DETAILS OF 1000-BU REINFORCED CONCRETE GRAIN BIN WITH FLAT WOOD AND PAPER ROOF

W. W. McLaughlin to Be 1940 Deere Medalist

SELECTION of Walter Wesley McLaughlin to receive the John Deere Gold Medal for 1940 seems a singularly happy choice in that his achievement fits well the purpose of its donors; that is, to recognize advancement in the application of science to soil in ways that redound substantially to human weal. Fellow workers who have watched the unfolding of the soil and water resources of the West, say that McLaughlin deserves a place beside that dean of desert and valley, the late Elwood Mead.

WALTER WESLEY MCLAUGHLIN

Mr. McLaughlin was born in 1876 at Nederland, Colorado, son of James S. and Susan Black McLaughlin. He was graduated in 1896 from Utah State Agricultural College as a bachelor of science in civil engineering. He returned, after about three years in mining engineering, to teach chemistry for a couple of years. This led him into studies of irrigation with particular attention to soil chemistry and soil physics, and in 1903 he went into these subjects as a research worker. Within a few years began a series of reports and bulletins dealing with injurious salts produced in soils as a result of irrigation, and their effect on crops; also with the physical characters of soils in relation to plant life.

From that start in 1903 as assistant irrigation engineer, his whole career has been one of steady advancement in the U. S. Department of Agriculture, except for service in 1911-14 as professor of irrigation and drainage at Utah State Agricultural College. In 1925 he became assistant chief of the Division of Irrigation, and in 1930 reached his present rank as division chief. He is also consulting engineer to the chief of the Soil Conservation Service, advising on all irrigation aspects of the Service, including administration of the Water Facilities Act; and water policy consultant of the U.S.D.A. Office of Land-Use Coordination. His degree of master of science in soil physics and irrigation was conferred by the University of California in 1924.

As with all awards thus far made by the Jury of Awards of the American Society of Agricultural Engineers, Mr. McLaughlin's selection seems to be based not on any single spectacular discovery or development, but on the summation of a career. Landmarks there have been, of course. One was his early discovery and experimental demonstration that under conditions of equilibrium the water content of a soil decreased as distance above the water table increased. This pointed the way to development of the mathematical theory now so well known and widely used.

"McLaughlin's work has not been spectacular," says one of his associates. "His influence on irrigated agriculture has been out of all proportion to the notice he has received in the public press. He always has been interested in the problems of the 'dirt' farmer as opposed (often quite literally) to those of the promoter, the financier, the city chamber of commerce, or such other groups as hoped to profit immediately from the construction of irrigation works. As a result he has seldom been in the forefront of the booster group.

"Doubling the area irrigated in a valley by building a new canal or reservoir makes much more show than getting the same result through more efficient use of facilities already existing. Local pride forbids much publicity on correction of mistakes made when an enterprise was planned to irrigate two or three times as much land as there was water for. Research on such humdrum questions as the movement of moisture through the soil, the quantity of water required to produce a ton of hay, or the proper size of a farmer's ditch doesn't make good newspaper headlines. Yet all of these things are at the foundation of successful irrigation farming in the West today.

"Walter McLaughlin has a most amazingly intimate knowledge of men and places throughout the West. There seems to be hardly a valley he has not visited nor a village in which he does not know someone. Whenever a problem comes up, he is able to go to someone directly concerned or intimately in touch with the situation and give some quiet advice, often before the problem is generally recognized or the dispute broken out."

"As I have had opportunity to observe Mr. McLaughlin's work over the years," says another man highly placed in the Department of Agriculture, "it has seemed to me that perhaps his greatest attribute has been his skill in handling human relationships. He has developed to a very high degree the ability to make and maintain contacts not only among engineers but also with people in many other walks of life. I think this accounts in large measure for the success he has had in his work."

"In his capacity of leadership," says one of his Utah State colleagues, "he has inspired and directed research work by many men . . . on almost every phase of irrigation and drainage and made many significant contributions . . . consumptive use of water in irrigation; seepage losses from canals; flow of water in soils; design and construction of irrigation and drainage wells; use of water by crops; and so on and on."

As hinted in some of the citations, Mr. McLaughlin has proved his prophetic insight into the economics and sociology of irrigation agriculture. For many years he has stood as a firm though diplomatic force, both for fairness down to the smallest detail and for sound policy in its broadest national aspects. The story runs that he once quit a good job with a great railroad because he could not concur in a policy of intensive settlement on a basis of grain farming which he was convinced would ultimately prove disastrous.

Although never a popular or prolific writer, the total of his reports, bulletins, and technical papers if fully assembled would be impressive. In one obviously abridged list of two dozen major items are two papers presented to the International Soil Congress; others to the American Association for the Advancement of Science, the American Society of Agricultural Engineers, the American Geophysical Union, the Institute of Irrigation Agriculture, and others. Most of his bulletins and kindred *(Continued on page 68)*

O. B. Zimmerman to Be 1940 McCormick Medalist

BY his selection to receive the Cyrus Hall McCormick Gold Medal for 1940, Oliver Brunner Zimmerman becomes possessor of two of the highest honors in the power of the American Society of Agricultural Engineers to bestow. In 1935 he was raised to the rank of Honorary Member—something the Society has ever done but sparingly, and still more rarely as a promotion from the active grade of membership.

OLIVER BRUNNER ZIMMERMAN

Colonel Zimmerman was born in Galena, Illinois, September 2, 1873, the son of a school teacher. His boyhood was passed in Milwaukee, where he attended public schools and won a $1,000 scholarship to the University of Wisconsin. He was graduated in 1896 in mechanical engineering, receiving an M. E. degree in 1900 after nonresident study. Following graduation he taught four years in a Milwaukee high school, then returned to the university as an instructor in the engineering college, and later became assistant professor. He also served on the graduate faculty.

His industrial work began in 1905 as mechanical engineer and assistant superintendent of R. J. Schwab & Sons, a Milwaukee machining and foundry concern. In 1906 he joined the Hart-Parr Company, Charles City, Ia., pioneer tractor manufacturers, and remained there in an engineering capacity until 1909, when he went to the M. Rumely Company, LaPorte, Ind., as chief draftsman and mechanical engineer.

In October, 1911, Col. Zimmerman became associated with the International Harvester Company in its experimental engineering department, an affiliation which he retained, except for the interruption of the World War, until his retirement on pension. From 1912 until 1915, he served as advisory engineer to Harvester's European sales and manufacturing operations, with headquarters in Brussels, Belgium. Because of the war, he returned to the United States in 1915.

When the United States entered the war, he volunteered and was commissioned captain of engineers in February 1917, being promoted to major later in the same year. In 1924 he was commissioned lieutenant-colonel in the O. R. C. His war work in engineering was largely with the U. S. Engineer Mobile Army and Coast Defense. He was also a member of the Bureau of Standards staff and a member of the board of review, General Engineer Depot.

He returned to Harvester after the war and specialized in materials and standards. From 1922 to 1934 he was assistant to the manager of the engineering department, in charge of materials, standardization, research, and specifications. He was supervisor of the materials and standards division from 1930 until his retirement.

Since his retirement from the Harvester organization he has practiced as a consulting engineer, currently in conjunction with C. H. Wilson & Co., Chicago. From June 1938 to June 1939 he was research associate at the University of California, division of agricultural engineering, his chief subject being an investigation of sugar beet machinery.

Probably, if we were privy to the deliberations of the Jury of Awards, we would find Col. Zimmerman considered as highly for his methods and for his spirit of pioneering as for his tangible achievements. In nine years of teaching he proved (and in later life his students proved) his rare ability to put the *educere* into education. He was able in large measure to impart his own originality, initiative, courage, and habit of orderly technical thinking.

Among his pioneering may be mentioned studies with so-called low-grade fuels—kerosene, benzol, alcohol, etc.; the feeding of water with fuels for control of preignition; the conditioning of fuels as to atomization and temperature preparatory to combustion; increased compression for greater efficiency; and the use of oil as a cooling fluid to meet wide range temperature requirements. In the more theoretical realm he pioneered in advanced use of section moduli, moments of inertia, and kinematics. In the metallurgical field he pioneered in the use of closer chemical composition and heat-treatments of steels, and in the application of alloy steels.

All of these he made the servant of engineering economics, or the achievement of greater strength per pound and per dollar. Related thereto are his explorations in the prestressing of structures, best known to this Society through his classic papers on the wheel. It would be hard to estimate how much these varied theories and practices have contributed to the light-weight, low-cost tractors and machines of today.

To members of the A.S.A.E., Col. Zimmerman is an old friend, familiar through nearly two decades of consistent attendance at meetings, the presentation of notable papers, never-ending industry in committees and other official capacities ranging up to that of President in 1927-28. He is known, too, by his scholarly contributions to this and other technical journals. Among these a few of the more significant are: "Instant Angular and Linear Velocities in Complex Mechanisms," "Intra-Company Standardization," "Coordination of Theory and Practice in Design and Operation of Plows," "Tractor and Plow Reactions to Various Hitches," "The Application of Machinery to Agriculture," and "The Technical Determination of Stress Surges in Loaded Wheels."

Among the honors preceding the present one, Col. Zimmerman has been elected by order of the Council to life membership in the Society of Automotive Engineers; made a corresponding member of the Wisconsin Academy of Arts, Letters and Sciences in recognition not only of distinction but of active membership maintained for many years after his removal from the state; and was awarded the honorary degree of Sc. D. by Pennsylvania Military College, conceded second only to West Point in curriculum, prestige, and traditions.

Not ignoring his great work, as supervisor of materials and standards for the Harvester Company, in promoting intra-company standardization and improving materials specifications for purchasing methods, his culminating contribution was five years of intensive study into the functional stresses of wheels. The first comprehensive paper arising from these studies he presented at the 1934 A.S.A.E. an-

nual meeting—fittingly at Detroit, the home of the wheel. Another paper was given at the fall meeting of the Society the same year. Another is under way.

Yet his service to the technology and the profession of engineering is vastly more than incidental to his employment. Beside our own Society and the others already mentioned he has been a member of and active in the American Society of Mechanical Engineers, the American Society for Testing Materials, and other technical bodies to a total of ten, including the Committee on the Relation of Electricity to Agriculture and the National Committee on Corn Borer Control. During a total of 68 society-years he served on some 290 committees, in many cases as chairman.

That this was largely a labor of love is apparent not only from the myriad hours of his personal time and energy that Col. Zimmerman devoted to it, but also in the zest with which he pursued it and the pride with which he recalls its various accomplishments, especially those culminating in American Standards through the agency of the American Standards Association. It came to be almost axiomatic that when he was on a committee it moved—thoroughly and constructively.

One of the contacts he deems especially significant was the one in which he headed a delegation of A.S.A.E. members at the special invitational conference with President Coolidge at Rapid City in August 1927. This conference, prolonged at the President's request to several times its appointed length, marked the beginning of a new influence by agricultural engineers in national policy and of added authority for the A.S.A.E.

Next to his family, his friends, and his profession, Col. Zimmerman's great love has been athletics, not merely as sport, but with all the implications of clean living, hard fighting, fair dealing, and good nature—sportsmanship as the gentleman knows it. As a youngster, shortly out of college, he was a teacher at West Division High School, in Milwaukee, and doubled as athletic coach. So well did his team perform that by the second year they were winning state championships. At the close of the third year, again filled with athletic success, his friends presented him the finest obtainable split-second chronometer works complete with gold case and chain—the same timepiece which, after 40 years continuous operation, he carries with undiminished pride today.

Though space now forbids further citations from his colorful career, readers may recall (or refer to) what was said of him in these pages, issues for August 1934 and June 1935. With all his colleagues we hope that as we honor him, so will he continue to honor us with the richness of his experience, the ripeness of his judgment, the pleasure of his personal association.

W. W. McLaughlin 1940 Deere Medalist

(Continued from page 66)

publications have been issued by the Utah State Agricultural College and by the U. S. Department of Agriculture. He is the author of numerous technical articles in English journals as well as of similar articles here.

Mr. McLaughlin has been a member of the American Society of Agricultural Engineers since 1925. Other of his memberships include the American Geophysical Union, Western Soil Science Society, California Economic Research Council, Commonwealth Club of California, Utah Society of Engineers, and the International Society of Soil Science. He and his wife, nee Phoebe Eliason, are the parents of one child, Mrs. Anna Demsey.

A Small Low Cost Concrete Grain Bin

(Continued from page 65)

curved mesh reinforcement to both sides of several studs, then carry this entire section over to the bin foundation rather than to place each stud separately in the foundation and later fasten the mesh reinforcement to the studs. This procedure applies only to the first course height of mesh reinforcement.

After all of the sections of wall reinforcement were in place, with mesh reinforcement 2 ft high, a stiff concrete mix was tamped and rodded lightly into place between the two rows of mesh. To our surprise it was discovered that the placing of concrete could continue rapidly since there was no tendency for the fresh concrete to pull the wall out of shape. A stiff concrete mix of one sack of cement to 2¾ cu ft of sand to 3½ cu ft of gravel, with 4½ gal of water added per sack of cement for average moist sand was used. Gravel was 1-in maximum size. As placing of concrete progressed, additional courses of mesh reinforcement were fastened to the metal studs until the required wall height was obtained.

Both exterior and interior surfaces of the bin were then plastered with portland cement plaster coats to cover and protect the metal reinforcement. A layer of cement plaster about ½ in thick was provided on the inside and ¾ in outside. Plaster was one part portland cement to three parts sand with 10 lb of hydrated lime added per sack of cement. The cement plaster is applied on a damp wall and should be moist-cured for at least three days. A waterproof portland cement wash was also applied to the damp cement plaster on the outside of the bin after the plaster was well hardened. The cement wash is also moist cured for three days.

As indicated in the drawing, the outside row of mesh reinforcement was carried up past the ends of the roof joists so that the exterior coat of cement plaster provides protection up to the level of the roof sheathing. Floor and roof construction progressed as shown in the plans and as outlined above.

CONCLUSIONS

Careful consideration of results obtained indicates that this type of construction will make a very satisfactory low-cost farm grain bin. No construction difficulties were encountered. In fact, the speed and ease with which the building progressed, using inexperienced help, indicates that the construction is thoroughly practical for average rural builders or for farmers possessing more than average skill in building. It is, however, important that a skilled plasterer be employed to assure good appearance of the bin. Care must be used in construction of the roof to make it entirely weathertight. A slight slope to the roof would be an improvement and may readily be effected by notching the underside of joists on one side of the bin. It was also found that the filling hatch should project somewhat higher above the roof level.

Experience gained in construction of the experimental bin indicates that an average farm building crew can build the 1000-bu bin with an expenditure of about ten man-days of labor. Average material cost in the Middle West will approximate 13 to 15 cents per bu for the 1000-bu bin, and 10 to 12 cents for the 2000-bu bin. Thus the complete bin may generally be had at a cost which compares favorably with types now commonly built.

NEWS

Pacific Coast Section to Share Program with Irrigation Equipment Dealers

WHEN the Pacific Coast Section of the American Society of Agricultural Engineers meets at Corvallis, Ore., February 16 and 17, the afternoon of the first day will feature a joint session of the Section with irrigation equipment dealers. Agricultural engineers are also invited to attend the morning session of the dealers on the same day, when the only item on the Section program is registration.

Features of the joint session will be a welcome by Dean Wm. A. Schoenfeld, School of Agriculture, Oregon State College, and papers on "Tests of Electric Steam Boilers," by J. R. Tavernetti; "Economical Design for Pipe Size for a Sprinkler Irrigation System," by R. E. Gladding; "Terracing in Semiarid Regions," by D. A. Williams; "Terracing in High Rainfall Areas of Western Oregon," by D. L. DuBois; and "The Availameter and Its Use in Soil Moisture Control," by R. B. Allyn.

A dinner and business meeting is to be held in the evening. An entertainment feature at this time will be a presentation of snow surveying under the title of "Hawkshaws on Skis," by R. A. Work.

On Saturday morning, February 17, the program will cover "Utilization of Farm Wastes," by Hobart Beresford; "A New Method of Air Measurement," by C. I. Branton; and "Developments in Flax Processing Machinery," by W. M. Hurst. There will also be an inspection trip through the laboratory of the agricultural engineering building, Oregon State College, and a demonstration of the Forest Service trail-building tractor.

Farm structures will be featured in the afternoon session. Papers scheduled include "Recent Lumber Developments of Agricultural Interest," by Albert Hermann; "Adaptability of Concrete and Concrete Floors for Farm Buildings and Homes," by G. F. Steigerwalt; "Prefabricated Buildings," by H. R. Sinnard; and "My Experience with a Prefabricated Residence," by F. R. Merryfield. An inspection trip will be made to the home of Mr. Merryfield to see the prefabricated house discussed. This will conclude the Section meeting program.

Washington News Letter

from AMERICAN ENGINEERING COUNCIL

ANNUAL ASSEMBLY REVIEWS A YEAR OF PROGRESS

CONSIDERATION of the work of its committees during the past year and of suggestions for further avenues of public service by several guest speakers occupied the attention of the 84 representatives of national, state and local engineering societies who attended the twentieth annual assembly of American Engineering Council, in Washington, January 11 and 12.

The first formal event of the meeting was a luncheon at which John M. Carmody, administrator of the Federal Works Agency, was honor guest. Mr. Carmody described the various federal activities that have been brought together to form FWA and stated that, although numerous economies have already been effected, much yet remains to be done to eliminate duplication of effort. It has seemed advisable, however, to move cautiously in making changes in established groups that have, in many cases, been functioning successfully for a great many years, lest more harm than good result. The agency is still evolving, and Mr. Carmody invited suggestions for its improvement.

The first session of the Assembly, which followed, was devoted entirely to a consideration of the reports of several of Council's committees, with the major portion of time devoted to the matter of Council's reorganization. The report of Executive Secretary F. M. Feiker reviewed in detail the consideration that had been given this problem up to the time of the meeting. President William McClellan spoke for the Special Joint Committee on Reorganization, stating that every effort will be made to complete its deliberations and submit a definite plan for the future within 90 days. He particularly emphasized the fact that there is no doubt that Council will be continued in some form; the points at issue being how extensive its work shall be and how best it can be financed to permit the carrying out of this work.

The temporary uncertainty as to Council's future course was reflected in the reports of two other committees. The finance committee withheld the approval of a definite budget for 1940 pending the report of the Special Joint Committee, and merely directed the executive committee to keep expenditures within Council's income, which will be substantially the same for 1940 as it was for 1939. The Committee on Constitution, By-Laws and Standing Rules likewise deferred its recommendations for changes until they could be made to dovetail with the future course of Council.

A.S.A.E. Meetings Calendar

February 16-17, 1940—Pacific Coast Section, Corvallis, Ore.

June 17-20, 1940—Annual Meeting, State College, Pa.

August (last week, tentative)—North Atlantic Section, Orono, Me.

December 2-6, 1940—Fall Meeting, Chicago, Ill.

Reporting for the Committee on Membership and Representation, chairman Warner Seely announced that during the year two new organizations had joined Council, bringing its roster to the highest point in its history—54 member organizations. The new members are the Institute of Ceramic Engineers and the Nebraska Engineering Society.

Presentation of the A.E.C. BULLETIN in printed form, which started with the February, 1939, issue, has greatly increased its readability, according to the report of the Committee on Regional Activities, presented by Eugene W. O'Brien, chairman. Its circulation has increased from 1,500 to over 4,000 copies per issue, and inquiries are frequently being received that will eventually result in a still higher figure. The Committee urged those attending the assembly to call the attention of their societies to the availability of this convenient and low-priced means of keeping in touch with Council activities and newsworthy developments in Washington.

SECOND SESSION

Friday morning, January 12, was devoted to a special report by the Committee on Public Affairs dealing with the participation of engineers in matters affecting the public interest, and to the presentation of two possible fields of service for engineers—the settling of labor disputes and the promotion of friendly relations with the countries of Central and South America.

The committee report summarized and presented specific examples from the returns of a questionnaire circulated among the member societies of Council. It revealed that, aside from his professional duties, the engineer as a citizen is quick to volunteer his services, both individually and through committee activity, in solving a wide gamut of problems ranging from the preparation of boiler codes and citizenship manuals, through such special services as advice on municipal improvements, to the sponsorship of Boy Scout troops, the support of homes for crippled children, and many others too numerous to list here.

That the engineering profession offers a fruitful source of individuals qualified by training and temperament to take over the exacting duties of acting as mediators or arbitrators in solving disputes between labor and management was the thought presented by Chairman Otto S. Beyer of the National Mediation Board. The selection of such men is difficult, since they must have a working knowledge of conditions in the industry concerned, yet cannot be identified with either labor or management. Mr. Beyer suggested that the profession give active consideration to ways and means of making available, from its numbers, the names of "broadminded, intelligent, socially-conscious, and technically well-informed" individuals willing to undertake such tasks.

Prof. F. N. Menefee of the University of Michigan opened the Pan-American topic by suggesting a program of summer employment by American industry of students in this country from Central and South America. The students, he argued, would benefit by supplementing theoretical training with practical experience; the industries would acquire valuable good-will through

the enlarged conception of the quality of American products that would result from close association with their manufacture.

In discussing Mr. Menefee's paper, Richard Pattee, of the State Department's division of cultural relations, revealed that eleven Pan-American countries have already ratified a treaty providing for the annual exchange with each of them of two graduate students and one professor. Funds are available for putting the plan into effect, and he suggested that the engineering profession should take some responsibility for presenting to the State Department the names of professors or graduate students willing and qualified to spend from three months to a year under such an arrangement.

Following the morning session a luncheon meeting was held at which the honor guest was Commissioner of Patents Conway P. Coe, who later gave a short talk touching on some of the aspects of the first beginnings of the patent system. He also pointed out that in a time of economic dissatisfaction almost any established institution is apt to be assessed with part of the blame, and that some current suggestions for radical changes in the patent system can be attributed to this cause.

FINAL SESSION

At the third session of the Assembly, held during the afternoon of January 12, consideration was given to several additional committee reports. Dean A. A. Potter, chairman of the Patents Committee, reported that the Joint Patent Inquiry, which was authorized at the 1939 Assembly, is now drawing to a close and a report will within a few weeks be submitted to the three sponsoring organizations: American Engineering Council, the National Association of Manufacturers, and The Conference Board.

The Committee on the Economic Status of Engineers sponsored talks by A. C. Shire, technical director for the U. S. Housing Authority, who told of negotiations resulting in the preparation of a schedule of maximum fees for services connected with architectural, engineering, and allied services, and Arthur S. Flemming, a member of the U. S. Civil Service Commission, whose topic dealt with current problems of federal personnel administration. According to Mr. Shire, a major difficulty met with was the difficulty of procuring figures indicating the costs of professional services, and it was therefore necessary, in evolving a schedule of fees, to adopt empirical methods with the hope of correcting injustices by later revisions when such data become obtainable.

Commissioner Flemming cited figures to show the tremendous increase in the work load of the Civil Service Commission during recent years, which it has had to carry with a slight increase in personnel. He pointed out that unless the merit system can be made to operate smoothly and efficiently, so as to provide the operating agencies of the government with qualified workers without undue delay the inevitable reaction will be away from the whole idea of a merit system, and cited with gratification the fact that his commission is one of the few for which an increased amount has been recommended in the President's budget for the coming fiscal year.

Reporting for the Committee on Surveys and Maps, chairman John S. Dodds stated that the work of Council has been partly responsible for a large increase in public interest in the problem of procuring adequate maps of the United States. Recommendations of Council have been embodied in a joint letter to Congress signed by the Secretaries of War, Commerce, and Interior, which calls for the adoption of a sustained program of appropriations to place the mapping program on an orderly basis. Many organizations throughout the country have taken official action to endorse this program. Professor Dodds also read a letter from Director Colbert of the U. S. Coast and Geodetic Survey, complimenting Council for its activities in support of a mapping program.

Chairman Alonzo J. Hammond of the Committee on Public Works reviewed the long-continued efforts of Council to bring about the creation of a Department of Public Works in the federal government, which has obtained substantial fruition through the establishment of the Federal Works Agency.

The report of the Committee of Tellers announced the election of officers as follows: President (two-year term), Alonzo J. Hammond, consulting engineer, Chicago; vice presidents (two-year terms), William L. Batt, president of SKF Industries, Inc., Philadelphia, and Col. Donald H. Sawyer, Federal Works Agency; treasurer (one-year term), Leonard J. Fletcher, Caterpillar Tractor Company, Peoria, Ill.

ALL-ENGINEERS' DINNER

As the final event of the meeting, 21 local chapters of the various engineering societies joined with Council in staging a dinner attended by 300 persons. The speaker, Dr. William T. Foster, director of the Pollak Foundation, took issue with the orthodox theories of economics that direct all efforts toward maintaining production, leaving consumption to shift for itself, and advanced the proposal that some effort should be devoted to regulating the monetary system so as to ensure uniform ability to consume. This idea, he said, is anathema to the orthodox economist, who closes his eyes to the obvious maladjustments that have resulted from the application of the traditional economic concept. It is therefore incumbent upon the engineer, whose efforts have freed production from its limitations, to take over the job of encouraging consumption, thus insuring himself of a continued job in the production of goods and services.

The assembly passed a number of resolutions thanking the speakers who had contributed of their time and thought to the meeting, the Conference of Secretaries for its participation, and others who had helped to make it a success.

* * *

POWER COSTS ANALYZED

Residential, commercial and industrial bills for electric power in the 48 states as of January 1, 1939, are analyzed in a comprehensive 73-page report issued by the Federal Power Commission. Data for this study are taken from the Commission's rate series, already issued for each state. The report is designated as F.P.C. R-17, and can be obtained from the Commission for 10 cents per copy. It is in five parts, the first comparing bills in the various classes by states and geographic regions; the second comparing bills according to sizes of communities; the third those submitted by private and by public utilities; the fourth, electricity costs in 1935, 1937, and 1939. The final section discusses the statistical methods used in averaging the data contained in the state series.

In a separate release the Commission reports that the average daily production of electric power for public use during November, 1939, established a new all-time high for the third consecutive month. For the 30 day period, production totalled 11,456,100,000 kilowatt-hours, a daily average of 381,870,000. This is an increase of 1.4 per cent over October, 1939, and 13.4 per cent over November, 1938.

RFC WILLING TO BUY SMALL MORTGAGES

In an effort to stimulate the construction of low-cost residences the Federal Loan Agency has announced that the RFC Mortgage Company, a subsidiary of the Reconstruction Finance Corporation, will henceforth purchase, at par, mortgages on homes not exceeding $7,500 in cost, when insured by the Federal Housing Administration for construction starting after January 1, 1940. Such loans carry a rate to the borrower of 4½ per cent plus a ½ per cent service charge. The existence of a ready market for such loans is expected to encourage local banking institutions to make more of them.

* * *

EXTRACTS FROM THE ANNUAL REPORT OF THE EXECUTIVE SECRETARY

Forums. Requests for holding forums have been received from a number of communities but because of the limited funds of Council it has been necessary to withdraw from developing this activity during the remainder of the year 1939. Committees of Congress, federal agencies of the government, and private organizations have freely used copies of the proceedings of the forums held in Philadelphia, Detroit and Washington. More than four thousand copies of the proceedings have been distributed both within and without the profession. Evidence grows that this particular method of recording engineering opinion on questions of public interest in forum discussions constitutes one of the most practical ways in which the engineering profession may transmit to public agencies factual data and opinions representing a diversified and intelligent viewpoint.

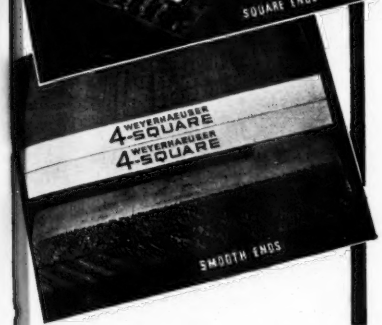
Surveys and Maps. Senate Document No. 54 comprises a memorandum embracing fundamentally the recommendations of the Committee on Surveys and Maps of American Engineering Council, of which Vice President John S. Dodds of Council is chairman. Funds so far have not been provided by Congress in sufficient amount to insure a development of this program, which was backed by the Secretaries of War, Interior and Commerce.

Patent Inquiry. As announced at the annual meeting, funds for salaries, travel and miscellaneous expenses for an inquiry into the American patent system were provided by the National Association of Manufacturers through the Conference Board in the amount of $22,500. The disbursement of this fund has been in the hands of The Conference Board, salaries and expenses being paid by them directly for the staff without passing through the books of American Engineering Council.

Beginning February 15, Professor Fairfield E. Raymond was employed as Director of the Inquiry. American Engineering Council has provided office space, miscellaneous services and a limited amount of staff time.

The Patent Inquiry constitutes one of Council's basic studies on social and basic questions, of which eleven have been undertaken, the first being the so-called "Waste In Industry" inquiry. As in the case of the other inquiries, this particular study is under the direction *(Continued on page 72)*

FARM BUILDING UNDER IMPROVEMENT



Correctly designed Farm Structures, made of good lumber, have far longer life—greater adaptability to new needs.

Fundamental is the task of the designer to meet the functional and structural requirements of a building at the lowest possible cost. His job concerns methods and it concerns materials.

Lumber has long been recognized as an economical building material for farm structures. Weyerhaeuser has further contributed to that economy, through its manufacture of modern, improved, 4-Square lumber.

This trade-marked lumber is properly seasoned. It is available in a wide variety of grades and species to meet every structural requirement. It comes in accurate lengths. It is squared at ends and edges. 4-Square lumber is ready-to-use lumber.

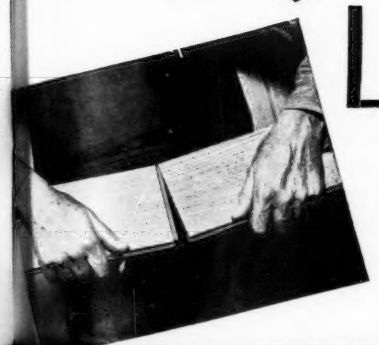
Into the plans that call for a maximum use of its standard lengths, 4-Square lumber is ready for erection without needless sawing or fitting. The result is a saving in erection costs and a reduction of material waste.

Correctly designed farm buildings, made of good lumber, not only give more years of substantial service — but give also the extra value of continuing service. Because of the nature of their materials, they can be economically remodeled to meet new needs. In this way, good lumber makes a further contribution to building economy.

4-SQUARE LUMBER

WEYERHAEUSER SALES COMPANY · ST. PAUL, MINNESOTA

A Weyerhaeuser Publication of interest to Farm Structure Engineers is "The High Cost of Cheap Construction", which includes "The Principles of Good Construction".



"ENDLESS" LUMBER

Weyerhaeuser produces End-matched lumber of soft wood sheathing, siding and flooring. This lumber has no set length. It locks at ends and edges to form a continuous course and a smooth, tight, rigid panel of any desired area. There is no waste with 4-Square "Endless" lumber — no cutting and fitting of each piece, because it is not necessary to break joints over framing members. The only sawing necessary is at the end of the course. Pieces sawn from the end of one course may be used to start the next course.

WEYERHAEUSER 4-SQUARE LUMBER

Washington News Letter

(Continued from page 70)

of a committee of American Engineering Council — the Committee on Patents, of which Dean Andrey A. Potter of Purdue University is the Chairman. Dean Potter will report to the 1940 Assembly on the progress of the Patent Inquiry.

Special Advisory Civil Service Committee. With the approval of President McClellan, Gano Dunn, engineer and scientist member on President Roosevelt's Committee on Civil Service Improvement, in cooperation with the staff of American Engineering Council developed two special advisory committees. Probably no more important step has been taken to present the viewpoint of the professions in the direction of improving the quality of the professional grades of the Civil Service. Mr. Dunn has expressed himself as highly pleased with the cooperation rendered by the profession through these committees. The service rendered is typical of the type of interprofessional questions to which Council lends itself as an instrumentality of its member organizations.

Do You Want Publications on Hydraulic Subjects?

COMPILATIONS of hydrologic data from small watersheds at nine of the S.C.S. conservation experiment stations will be included among forthcoming U.S.D.A. publications and will cover rainfall, surface runoff, and soil loss data for the period of 1931 to date, as obtained from small watersheds subjected to various cover and land use.

A recent act of Congress, however, prohibits the distribution of government publications to any individual who has not expressed a desire in writing for such publications. The U.S.D.A. issues a monthly list of publications, and any person may arrange to have this list mailed to him as issued, by writing to Office of Information, U. S. Department of Agriculture, Washington, D. C. Any publication listed therein will be mailed upon written request to the Department.

Fred Jones Made Texas Department Head

WORD has just been received of the formal appointment of Fred R. Jones as head of the department of agricultural engineering at the A. & M. College of Texas, College Station, succeeding the late Dan Scoates. He has been acting head of the department for some time.

Mr. Jones, born and reared in Wisconsin, graduated from the University of Wisconsin in 1915 with the degree of bachelor of science in agriculture, and in 1931 received his master's degree in agricultural engineering from Iowa State College. Upon graduation he served a year as instructor in the agricultural engineering department at the University of Wisconsin, and then a year as extension specialist in agricultural engineering at the Mississippi State College. Following a year in the Air Service of the U. S. Marine Corps during the World War, he served for two years as a salesman for the John Deere Plow Company, joining the teaching staff of the agricultural engineering department at the A. & M. College of Texas in 1921, with which he has since been associated.

Mr. Jones is a Fellow of the American Society of Agricultural Engineers, and has been a member of the Society since 1917. He is a member of Alpha Zeta, a member and past master of Brazos Union Lodge, A.F. & A.M., and a member and chairman of the board of stewards of the First Methodist Church at Bryan, Texas. He is author of the textbook "Farm Gas Engines and Tractors" used by the agricultural engineering departments of all of the leading agricultural colleges in the country. He is also author of several bulletins and articles on farm power and equipment.

Frank Zink in New Position

FRANK J. ZINK has resigned from his position as research engineer in the tractor division of the Allis-Chalmers Manufacturing Company, to become sales manager of the Litchfield Manufacturing Company of Waterloo, Iowa. He is an agricultural engineering graduate of Iowa State College.

Before joining the Allis-Chalmers organization Mr. Zink was in agricultural engineering work successively in connection with the Iowa rural electric field laboratory, Iowa State College, Westinghouse Electric and Mfg. Co., and Kansas State College. In his new work he will have charge of the sale of manure spreaders, the main product of the Litchfield organization, and other specialties in the farm equipment field which it is planning to put on the market.

Necrology

LOUIS THEODORE JESSUP, drainage engineer, Soil Conservation Service, U. S. Department of Agriculture, passed away October 1, 1939. Information of his passing was not received in time for earlier announcement.

Mr. Jessup was born in Latah, Wash., in 1889 and in 1913 received the degree of B.S. in C.E. from the University of Idaho. During 1910 and 1911 he worked underground in the Coeur d'Alene mining district, on machine work and timbering. During the summer of 1912 he was with the U. S. Forest Service, laying out and building trails, and making preliminary surveys for logging roads and traverse surveys in the St. Maries District. In June, 1913, he was appointed principal assistant for the U. S. General Land Office and during that summer was engaged in subdividing townships in the mountains of central Idaho. In September, 1913, he was appointed assistant drainage engineer with the Office of Experiment Stations, and continued as a drainage engineer in government service for the remainder of his life. The thoroughness and efficiency with which Mr. Jessup carried on the investigational work assigned to him and presented the data developed, in reports and bulletins, won for him high commendation.

For the past several years, he had represented the Department of Agriculture in the international Kootenai River Project in Idaho and Canada, and had appeared in hearings before the International Boundary Commission in both Canada and the United States. He was entrusted with many special assignments where a high degree of technical knowledge and good judgment were required, and had represented many federal agencies.

Mr. Jessup had been a member of the American Society of Agricultural Engineers since 1930.

Personals

Julian M. Fore has been appointed an assistant agricultural engineer, commerce department, Tennessee Valley Authority, Knoxville, Tenn. He was formerly on the faculty of the agricultural engineering department at Purdue University.

R. W. Louden, advertising manager, Louden Machinery Company, was recently elected to the board of directors of his company.

H. P. Smith and M. H. Byron are two of the four authors of Texas Agricultural Experiment Station Bulletin No. 580, on "Mechanical Harvesting of Cotton as Affected by Varietal Characteristics and Other Factors."

L. J. Smith and W. A. Junnila are authors of the fifteenth annual Progress Report of investigations of the uses of electricity for agriculture in the State of Washington.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the January issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

C. O. Bunnell, farm service supervisor, Pacific Power and Light Company. (Mail) P. O. Box 514, Yakima, Wash.

Stanley Bidlack, senior rural representative, Philadelphia Electric Company. (Mail) 327 Chestnut Street, Coatesville, Pa.

W. Joseph Cullen, associate editor, The Chek-Chart Corporation, 624 South Michigan Avenue, Chicago, Ill.

Milton Henderson, agent, Bureau of Chemistry and Engineering, U. S. Department of Agriculture. (Mail) 614 Sixth St., Ames, Iowa.

Fred Meyer, Jr., junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) P. O. Box 83, Garden City, Kans.

Harold F. Morgan, engineer, Farm Security Administration, U. S. Department of Agriculture. (Mail) Box 298, Greensboro, Ga.

Sydney C. Partridge, general manager, industrial division, Timken Roller Bearing Company, Canton, Ohio.

George T. Ridings, 5106 Washburn Avenue, So., Minneapolis, Minn.

A. H. Scrimshaw, instructor, Farm Mechanics, Extension Department University of Alberta, Saskatoon, Saskatchewan, Canada. (Mail) 1208 Victoria Avenue.

Elmer E. Williams, distribution manager and chief inspector, DeKalb Agricultural Association, Inc., DeKalb, Ill. (Mail) 623 North Sixth St.

TRANSFER OF GRADE

Louis M. Glymph, Jr., associate agricultural engineer, Sedimentation Division, Soil Conservation Service, U. S. Department of Agriculture, 715 Columbian Bldg., Washington, D. C. Junior to Member.

Ira E. Hamblin, assistant agricultural engineer, Mississippi Experiment Station, State College, Miss. Junior to Member.

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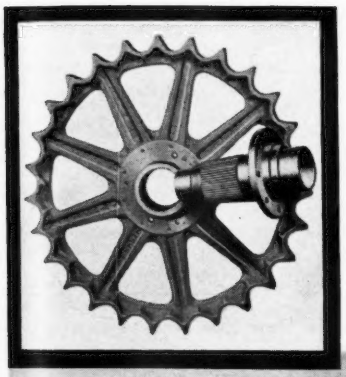

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Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers thereof, whose names and addresses may be obtained on request to AGRICULTURAL ENGINEERING, St. Joseph, Michigan

EFFECT OF SOIL TYPE, SLOPE, AND SURFACE CONDITIONS ON INTAKE OF WATER, *F. L. Duley and L. L. Kelly.* (Coop. U.S.D.A.) Nebraska Sta. Res. Bul. 112 (1939), pp. 16, figs. 5. The authors sprinkled 0.005-acre plats of various soils from an overhead oscillating sprinkling device with fan-shaped nozzles. A constant water head was maintained by pumping from a large supply tank into a smaller, elevated, constant-level tank. The rate of application was determined by a special water meter, and the runoff was measured in a two-compartment tank calibrated to 0.001 in of runoff from the plat area. The time required for a given runoff to take place was read on a stop watch. From these data, rate curves for both runoff and infiltration were obtained.

The rate of intake of water at the beginning of application was often very high, decreasing rapidly at first, and finally reaching an approximately constant infiltration rate. The total intake of water and also the final infiltration rates on cultivated bare land showed much less variation among the different soil types than was anticipated. The soils tested varied greatly in the texture of the surface soil and in profile characteristics, but the quantity of water taken in during a given time was strikingly similar for all soils, and the infiltration rates were finally reduced almost to a common level. Even sandy soils closed up until infiltration was very slow.

The total intake and the infiltration rate decreased slightly with increase in slope. However, this change in infiltration rate was found very small and very gradual with changes in slope above about 2 per cent.

There seemed to be no consistent or significant difference in the rate of infiltration due to difference in the rate of application of water when the rate of application materially exceeded the rate of intake. With continuous application of water the rate of infiltration gradually decreased to a point where it became nearly, but not absolutely, constant. A plat which received water and was then allowed to stand for a short time showed a sharp decrease in the infiltration rate. However, upon standing for several days or a week and then receiving another application the infiltration rate approached a constant usually higher than that at the end of the previous application period. This rate was again reduced after the plat had again stood in a wet condition.

Soils covered with a crop showed a much higher rate of intake of water than bare soils and maintained this higher infiltration rate throughout extended tests. The denser crops like native sod and alfalfa showed the highest and the longest maintained infiltration rates. Sod land with grass clipped close and surface debris removed showed a rate only a little above that of bare cultivated soil. Soil covered with crop residue such as straw or other organic material gave an infiltration rate similar to or possibly higher than that obtained when the soil was protected by a dense growing crop. The total intake of water when the soil was thus protected was very great on all the soil types tested, and the high rate of intake was maintained over an extended period. In fact, it was sufficient to take care of an amount of water greater than that likely to be received during any rainfall period in Nebraska. Claypan soils (Pawnee clay loam and Butler silty clay loam) absorbed large quantities of water within a short period of time whenever the surface was protected by means of a straw mulch.

"There may be far greater variation between the rates obtained under different surface conditions on a single soil than would be shown by different soils having the same surface conditions. This may make it necessary to think of infiltration rates characteristic of surface conditions rather than of different soils. . . .

"The breaking down of soil structure, by the compacting effect of the rain and the assorting and rearranging of the soil particles by running water forming a compacted layer at the immediate surface, appears to be the principal reason for the low infiltration rates on cultivated land. The formation of this semipervious layer, often only a few millimeters thick, was largely prevented by a covering of straw or by a growing crop."

OLD LAYING HOUSES CAN BE MODERNIZED, *D. C. Kennard and V. D. Chamberlin.* Ohio Sta. Bimo. Bul. 198 (1939), pp. 62-64, fig. 1. The suggestions given are also deemed applicable to new construction.

SILO TYPES AND CONSTRUCTION, *J. R. McCalmont.* U. S. Dept. Agr., Farmers' Bul. 1820 (1939), pp. II+62, figs. 54. This bulletin supersedes bulletins on pit silos and home-made silos, Nos. 825 and 855, respectively. Following a brief discussion of possible types of soils and of the choice to be made of the type best suited to the purpose in hand, this bulletin takes up above-ground permanent silos, including monolithic concrete, concrete-stave, concrete-block, tile, brick, wood-stave, the modified Wisconsin, the wooden-hoop, the timber-crib, and metal silos, giving data on which to determine the dimensions necessary and much constructional detail in the case of each type. Drawings, dimensioned where necessary, and photographs illustrate this material.

Below-ground silo types dealt with in similar detail include pit silos and trench silos.

Temporary silos, the construction of which is dealt with in like manner, are fence silos and stack silos.

The bulletin contains also a conspicuously placed warning against gas danger in silos, describing a lighted lantern test for the presence of dangerous concentrations of carbon dioxide and simple means for effecting the diffusion of such accumulations before entering the silo. First-aid treatment of victims of silo gas suffocation is also briefly described.

AN OUTLINE OF THE WATER FACILITIES PROGRAM, U. S. Dept. Agr., Soil Conserv. Serv., [pp. 23], figs. 11. A popular, profusely illustrated outline is given, indicating what the water facilities program provides, where it applies, who may benefit, manner of handling construction and installation, limitation of size of single projects, repayment of loans, plans for tenants, etc.

REPORT ON THE AGRICULTURAL IMPLEMENT AND MACHINERY INDUSTRY.—I, CONCENTRATION AND COMPETITIVE METHODS. II, COSTS, PRICES, AND PROFITS. U. S. House Represent., 75. Cong., 3. Sess., Doc. 702 (1938), pp. XXI+1176, [figs.] 17, maps 3. This is a report, including conclusions and recommendations, of the Federal Trade Commission on the agricultural implement and machinery industry. Part 1 (pp. 1-390) "deals with the economic factors upon which the production and distribution of farm implements and machines is based, the history of developments by which the bulk of production and wholesale distribution both in domestic and foreign trade has become concentrated in the hands of a few large manufacturing companies, the extent of concentration of production by such companies, the nature of distribution organizations and agencies by which implements and machines are sold, the factory equipment and programs of operations of typical manufacturing plants, and competitive methods and practices pursued by both manufacturers and dealers, with special attention to methods and practices which may involve restraint of trade or tend to produce further concentration of control or monopoly in production and distribution." Part 2 (pp. 393-1038) deals with "the investments and profits of farm implement and machinery manufacturers, their varying costs of production for a variety of products, the prices received by manufacturers and dealers, the prices at which machines are sold in foreign markets, a comparison of the movement of the prices of farm machinery with the movement of the prices of other comparable commodities, and the investments and profits of retailers of farm implements and machines."

THE VALUE OF TREE-RING ANALYSIS IN ENGINEERING, *R. Lassetter.* Tree-Ring Bul. 5 (1938), No. 2, pp. 13-15. The author reports briefly on several studies in northeastern Tennessee as showing the value of the tree-ring technic as an aid in hydrological problems, viz, adaptation of the technic to tree growth in the area, determination of the degree of relationship between tree growth and hydrological phenomena, when a suitable relation exists to compute the approximate precipitation and runoff from tree growth values as far back as the growth curve extends, and if possible to learn something of climatic trends in the area. It is concluded that the relationships derived from tree growth appear to be satisfactory enough to be of definite value in approximating past hydrological conditions. *(Continued on page 76)*

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Agricultural Engineering Digest

(Continued from page 74)

HEATING AND LIGHTING GREENHOUSES WITH INTERMITTENT LIGHT, *J. M. Arthur and E. K. Harvill.* Contrib. Boyce Thompson Inst. 10 (1938), No. 1, pp. 15-44, figs. 6. Comparing an insulated, artificially lighted greenhouse with an ordinary greenhouse also supplied with supplemental light, it was found that dry weight and flowering were greatly increased in both as compared with control houses without supplemental light. Dry weight, however, was less in the insulated house, apparently due to the restricted CO_2 supply resulting from the low rate of air exchange. The comparative growth and development of hyacinths, *Lilium Longiflorum*, and gladiolus in the different environments is described.

CLOTH HOUSES, *A. Laurie and C. Link.* Ohio Sta. Bul. 594 (1938), pp. 37, figs. 5. In addition to presenting general information on the construction of clothcovered houses and the management of plants grown thereunder, the authors discuss the results of experiments with asters, chrysanthemums, and various annuals and perennials. In general, the authors conclude that the cloth house offers an opportunity for the commercial production of summer flowers of superior quality. Under white cloth there was a reduction of light amounting to 35 per cent and in temperature of from 5 to 8 F. The relative humidity under the cloth was somewhat higher than outside. Asters responded to shading with black cloth from 5 pm to 7 am, beginning from 7 to 8 weeks after planting. The use of supplemental light on asters in the seedling stage hastened flowering according to the variety grown. Under cloth, many annuals produced larger flowers with longer stems and better color. The shading of pompon chrysanthemums with black cloth from 5 pm to 7 am resulted in earlier flower production. Roses produced under cloth were equal or superior to those grown in the greenhouse in the summer season. The cloth greenhouse proved desirable, also, for holding certain stock plants such as pelargoniums.

STUDIES OF THE TOMATO IN RELATION TO ITS STORAGE.—I. A SURVEY OF THE EFFECT OF MATURITY AND SEASON UPON THE RESPIRATION OF GREENHOUSE FRUITS AT 12.5 C., *E. J. M. Walford.* Canad. Jour. Res. 16 (1938), No. 2, Sect. C, pp. 65-83, figs. 38. Grand Rapids tomatoes were grown in the greenhouse at different seasons, individual fruits were picked at various stages of maturity, and continuous records were taken on their respiration at 12.5 C. (54.5 F.) The fruits of the late spring and summer went through the customary series of changes in respiration rate as they ripened, and exhibited the lack of durability usual in the tomato. In contrast, the fruits of the late autumn, winter, and early spring, when picked before the external appearance of red pigment, passed into a stable state in which ripening proceeded with but little change in respiration rate and with greatly enhanced duration of life at 12.5 C.

A METHOD FOR OBTAINING A CONTINUOUS MEASUREMENT OF SOIL MOISTURE UNDER FIELD CONDITIONS, *G. J. Bouyoucos and A. H. Mick.* (Mich. Expt. Sta.) Science, 89 (1939), No. 2307, p. 252. The moisture content of a standardized block of $CaSO_4$ (gypsum) buried in the soil varies directly with that of the soil and may be measured by determining the electrical conductivity of the block by means of electrodes and a form of the Wheatstone bridge. A high degree of accuracy is reported.

EROSION AND RELATED LAND USE CONDITIONS ON THE ELM CREEK WATERSHED, TEXAS, *H. Oakes and E. Somerville.* U. S. Dept. Agr., Soil Conserv. Serv. (1939), pp. 20, pls. 5, fig. 1, maps 2. Conditions on this watershed, which comprises 159,195 acres all in farms, 84 per cent cultivated, and affected by erosion damage ranging from slight to very severe, are described. The survey shows that 137,053 acres have been affected by accelerated water erosion, 50,442 acres slightly, 52,674 acres moderately, 20,200 acres severely, and 13,737 acres very severely eroded and essentially ruined for further cultivation. Control and recovery methods of the usual type are recommended.

EFFECT OF CERTAIN CROPS AND SOIL TREATMENTS ON SOIL AGGREGATION AND THE DISTRIBUTION OF ORGANIC CARBON IN RELATION TO AGGREGATE SIZE, *W. H. Metzger and J. C. Hide.* (Kans. Expt. Sta.) Jour. Amer. Soc. Agron. 30 (1938), No. 10, pp. 833-843, fig. 1. Soil under growing corn and kafir in field and greenhouse showed as good aggregation under the sorghum crop as under corn. When oats succeeded these two crops in the field, however, soil samples from the oats stubble showed a greater degree of dispersion following sorghum than where corn was grown the preceding crop. Sweetclover left the soil better aggregated after one year's growth than did soybeans, while alfalfa and sweetclover gave similar results. Soil fallowed for two years in the field was less aggregated than soil fallowed for one year. Limed soil under sweetclover and red clover in a greenhouse experiment was more highly aggregated than unlimed similar soil under these crops. Unlimed and unbleached fallow soil in the greenhouse was as well aggregated as limed fallow soil. It is suggested that perhaps the combined action of lime and a legume crop, or possibly other crops, produces an aggregating force which lime alone does not exert. "The grasses failed to produce the aggregation of the soil expected of them, but their failure in this experiment may have been due to the shortness of the growth period."

THE EFFECT OF FLUE-CURING ON THE INFECTIVITY OF ORDINARY TOBACCO MOSAIC VIRUS (TOBACCO VIRUS 1), *J. A. Pinckard and L. Bozovaisky.* (Va. Expt. Sta.) Phytopathology, 29 (1939), No. 3, pp. 242-250, figs. 2. Tobacco virus 1 remained infective in flue-cured tobacco leaves throughout four of the first five barns cured and in the lower and middle tiers of the fifth (1937). Although it was completely inactivated in the lower tiers of seven barns of cured tobacco, the final drying temperatures were higher than ordinarily required for curing. In other parts of the same barns, maximum temperatures were both above and below the thermal limit of the virus. Temperature differences amounting to as much as 50 F were found within the same wood-fired barn. In five barns of tobacco cured with an oil-burning heating unit at no time was the thermal death point of the virus reached. Leaves infected with tobacco virus 1 lost weight and cure and became dry at the same temperature and time as did noninfected leaves. The temperatures required for a satisfactory "cure" varied, but were substantially below the thermal death point and time for complete inactivation.

THE EFFECT OF CALCIUM ON THE ERODIBILITY OF SOILS, *T. C. Peele.* (U.S.D.A.) Soil Sci. Soc. Amer. Proc. 1 (1936), pp. 47-58, figs. 7. Measurements of percolation rate, crushing strength, and penetration resistance are reported and discussed. A part of the results recorded were as follows:

"The addition of calcium carbonate to the B horizon of Appling, Davidson, and Cecil soils decreased the permeability in each case as measured by the percolation rate in artificially packed tubes. In the case of the Iredell soil the addition of calcium carbonate had little effect on the percolation rate, which was originally very slow. The addition to the Cecil soil of calcium chloride or calcium hydroxide caused a large decrease in the percolation rate. In the case of the hydroxide, however, this effect seemed partially to disappear after a large excess of calcium hydroxide had been added. The addition of calcium to the Cecil soil caused a decrease in permeability whether the calcium was added immediately before the permeability determination or composted for 2 mo prior to the determination. The addition of calcium carbonate to Appling, Davidson, and Cecil soils produced an increase in the percentage of aggregates having diameters between 0.03 and 0.01 mm, which could have occurred only by a decrease in the percentage of larger aggregates. The addition of calcium carbonate to Iredell had little if any effect on its state of aggregation."

NATURAL VEGETATION AS A FACTOR IN THE LOSSES AND YIELDS OF WATER, *J. Kittredge, Jr.* Jour. Forestry, 35 (1937), No. 11, pp. 1011-1015. Stating that for average forest conditions over large areas the seasonal interception will usually run between 10 and 25 per cent of the precipitation and may approach 0 per cent when the vegetation has been heavily grazed, cut, or burned, the author remarks that transpiration is the most difficult factor to evaluate. Available data suggest that annual transpiration for forests ranges between 5 and 15 in, but may reach 35 in in dense stands on the best sites. Different technics for estimating the role of vegetation in affecting water loss in forests are discussed, with suggestions as to problems which need further study.

SOIL EROSION BY WIND IN KANSAS. Kans. State Bd. Agr. Rpt. 56 (1937), No. 224-A, pp. 87, figs. 60. This bulletin deals with Soil Blowing in Kansas and Methods of Control, by R. I. Throckmorton and L. L. Compton (pp. 7-44), The Kansas Soil Drifting Law (pp. 45-47), Observations and Warnings of 1920 (pp. 48, 49), and Surveys of Soil Blowing, 1937 (County Summaries), by W. A. Atchison (pp. 50-86), made in cooperation with the Kansas State College and in compliance with the state law. It shows the substantial progress that has been made in developing and putting into effect practical methods of mitigating the causes and consequences of wind erosion of soil. It emphasizes especially the necessity of community action in putting into effect emergency measures as well as permanent programs. *(Continued on page 78)*

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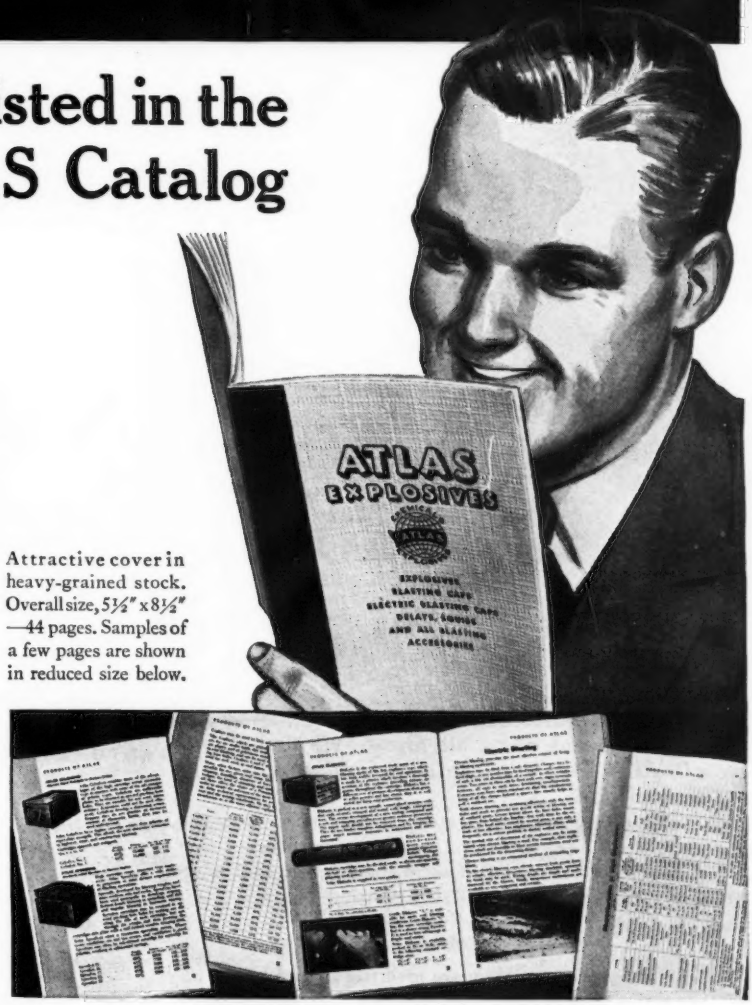

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Agricultural Engineering Digest

(Continued from page 76)

PRINCIPLES OF GULLY EROSION IN THE PIEDMONT OF SOUTH CAROLINA, *H. A. Ireland, C. F. S. Sharpe, and D. H. Eargle.* (Coop. S. C. Expt. Sta.) U. S. Dept. Agr., Tech. Bul. 633 (1939), pp. 143, figs. 96. This bulletin covers a general study of conditions which make the southern Piedmont particularly susceptible to gullying, and an investigation of the causes, mechanics, and rate of gully cutting in 12 representative gullies, largely untreated, in South Carolina, together with less detailed study of a much larger number. The authors find 4 distinct stages in the development of the deep caving gully characteristic of the southern Piedmont. "In stage 1, the channel-cutting stage, the gully works downward through the A and B horizons. Cutting in this stage is relatively slow, and this is the time at which protective measures can best be undertaken. Stage 2 begins when the gully penetrates the base of B horizon and begins cutting in the weak parent material. This stage, characterized by the headward migration of an overfall and plunge pool and by rapid caving of the walls and deepening of the channel, is much the most violent stage of gully growth and is the least favorable for the successful application of control measures. Caving and slumping of the walls and heads alternate with periodic clearing out of the caved material from the gully channel. Additional substages in the gully's growth may occur in the form of periods of headward progression of successive waterfalls or knickpoints, marking renewed channel cutting and deepening of the gully. Stage 2 ends when erosion is retarded because the channel reaches a graded condition under the control of some local base level. Stage 3 is a period of adjustment to the graded channel. Slopes of the gully walls are reduced by weathering, slope-wash, and mass movement; plants are able to get a foothold on the lowered slopes, and vegetation gradually brings about a healing of the gully. Stage 4 is a period of stabilization and is characterized by the slow development and accumulation of new topsoil over the old scarred surface. Rejuvenated cutting brought about by lowering of the base level or an increase in the amount of rate of run-off can at any time cause stage 3 or 4 to revert to stage 2."

Major climatic factors in gully erosion in the Spartanburg area are the intense cold-front rains and tropical hurricanes of late summer and early fall. Deep weathering of the igneous and metamorphic rocks of the Piedmont prepares the way for rapid erosion. Past and present land use, and periods of land abandonment, in particular, have been causes of sheet erosion and gullying.

FACTORS INFLUENCING THE QUALITY OF AMERICAN GRAPES IN STORAGE, *J. M. Lutz.* U. S. Dept. Agr., Tech. Bul. 606 (1938), pp. 27, figs. 13. Stored for the most part in 4-qt baskets without washing, grapes kept with the least shattering and decay at 32 F. Both shattering and decay increased as the relative humidity increased, but because of shriveling at low humidities a percentage of from 80 to 85 appeared most satisfactory. Loss of weight was correlated directly with temperature and inversely with relative humidity. With containers so arranged as to allow free circulation of air, 22, 29, and 39 hr, respectively, were required to cool the centers of 4, 16, and 32-qt baskets from 70 to 31 F, the storage temperature. Washing fruits generally caused a slight increase in decay. Treatment with sodium bisulphite resulted in decreased decay and shattering, but the practicability of its use is questioned because of injury hazard and the fact that grapes kept satisfactorily at 32 F without treatment. There were observed great differences in the keeping quality of different varieties, with Agawam, Brighton, Eumedel, Lindley, and Urbana among the best keepers. Temperature had a profound influence on respiration of Concord grapes, the output of CO_2 increasing from 2.74 mg per kilogram-hour at 32 F to 38.55 mg at 80 F. The refractometer gave a close approximation of the sugar content of the juice. The most significant effect of storage was a loss in acidity at higher temperatures. There was a slight increase in solids and acids at low temperatures, due, apparently, to water loss. During ripening on the vine, grapes increased in solids and decreased in acid content. Practical recommendations include careful handling, the removal of cracked berries, and the use of baskets of 12-qt size or less.

UTILIZING HEAT FROM THE SUN, *C. G. Abbot.* Smithsn. Misc. Collect. 98 (1939), No. 5, pp. [1]+11, pls. 4, fig. 1. The author discusses the quantity of solar energy available, intermittance and storage of solar power, water distilling and cooking by solar heating, recent commercial products a boon to solar devices, mechanism for following the sun, domestic water heaters, solar cookers, solar water distilling, the solar flash boiler for power, flash-boiler devices, automatic regulation of flow of boiler water, efficiency of solar flash boiler, competition of solar power against coal, oil, and water power, early experiments with solar power (1910), storage of solar heat or power, and the commercial use and cost of solar heating. *(Continued on page 80)*

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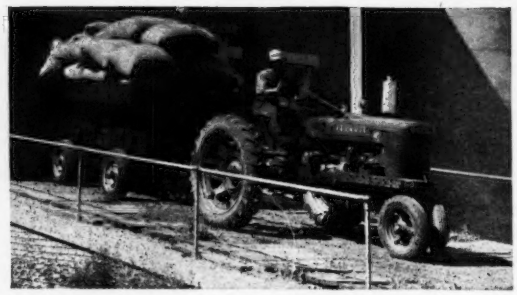

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(Continued from page 78)

THE DETERMINATION OF EVAPORATION FROM LAND AND WATER SURFACES, *C. W. Thornthwaite and B. Holzman.* U. S. Mo. Weather Rev. 67 (1939), No. 1, pp. 4-11, pls. 2, figs. 5. The importance and complexity of the problem of determining rate and amount of evaporation from land and water surfaces or transpiration from vegetation is stressed. In an effort to supply much-needed information, a method for determining evaporation from either land or water areas is presented in this preliminary report and its practicability is said to be demonstrated. It is also hoped that with proper instrument installation it will become possible to determine transpiration rates and moisture requirements of various field crops and forest trees, the effectiveness of various moisture-conserving practices, and the relative importance of evaporation and transpiration in the hydrologic cycle.

OFFICIAL TRACTOR TESTS, *H. F. McColly.* North Dakota Sta. Bimo. Bul. 1 (1939), No. 6, pp. 8, 9. This note presents a condensed statement of the Nebraska tractor law and calls attention to the availability, at the University of Nebraska, of copies of the annual bulletin reporting tests of tractors.

The Nebraska State law, to which reference is made, requires that a stock machine of any model of tractor to be offered for sale in Nebraska shall be tested for comparison of its performance with the claims made for it before permits for its sale are issued to dealers, and that a service station fully equipped with replacement parts shall be maintained in Nebraska and within reasonable shipping distance of the customer.

Literature Received

A MANUAL ON SHARPENING HAND WOODWORKING TOOLS, by J. K. Coggin, L. O. Armstrong, and G. W. Giles. Paper bound, 48 pages, 13 charts, 26 figures, 8¼x10¾ in. Practical illustrated explanations are given on how to sharpen wood chisels, plane irons, saws, auger bits, knives, axes, cabinet scrapers, and screw drivers. Interstate Press, Danville, Ill., 29 cents.

GROWING PLANTS WITHOUT SOIL, by D. R. Matlin. Cloth-bound, 137 + VII pages, illustrated, 5½x8¾ in, indexed. A popular elementary treatment of the subject for beginners and students, hobbyists, and commercial growers in this field. Chapters cover the history, advantages, and functions of plant chemiculture, relation of chemicals to plant and animal life, chemicals needed by plants, germination, formulas for nutrient solutions, preparation and use of formulas, and control of tank culture, construction of tanks, aeration, acidity versus alkalinity, sand culture, proper environment, how to make cuttings, hormones and auxins, directions for treating cuttings with auxin, budding and grafting, construction and operation of greenhouses, symptoms of plant food deficiency and excess in plants, description of deficiency symptoms in apple trees, and reaction of plants to chemicals. An extensive appendix includes some more technical data which would be of value as a reference for advanced students and practitioners of the art, such as chemical analyses of Los Angeles water, composition of chemicals used in nutrient solutions, atomic weights, positive and negative ions, tests for metals, tests with organic reagents, microchemical tests, chemical composition of foods, and a list of references. Chemical Publishing Co., New York, N. Y. $2.00.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS WANTED

AGRICULTURAL ENGINEER with B. Sc. degree from Virginia Polytechnic Institute, class 1928. Age 35. Health excellent. Single. Farm background. Could go to any location. Have completed the rural electrification sales training course with General Electric Company. Diversified agricultural engineering training, with 11 years' experience in employment of commercial concern in development of rural electrification. Desires employment with farm machinery, or utility company, or any branch of agricultural engineering extension work. Complete information and references furnished upon request. PW-315